Manual PV*SOL® 4.5

Design and Simulation of Photovoltaic Systems

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1 Operating Instructions

1.1 Operating Instructions

The programme is operated by using the menus, the symbols on the button bar and the mouse. The parameters on which the calculations are based are set in the appropriate dialogue window (see Main Screen).

PV*SOL® is a WINDOWS™ application, and the usual WINDOWS™ features and commands are incorporated as follows:

The formats for numbers, date and currency are as per the settings within the WINDOWS system control panel. If you change the settings in the system control panel you will have to restart PV*SOL® in order to activate the changes within the programme.

All graphics within the programme can be printed out. You are able to change the printer settings from within the programme.

The online **Help** facility giving information on all PV*SOL® dialogue windows and menus is available via the function key F1 or the **Help** menu. In the Help menu you can search under various headings and key words, and, by clicking on the green coloured text, you can go straight to the next link. Or you can simply scan through the individual help texts.

The Variant Comparison table, the tables within the Graphics facility and the Appliances - Load Profile can be copied and pasted into other spreadsheet programmes such as EXCEL.

1.2 Activation of the Programme

1.2.1 Serial Number

If you have purchased the programme, you will have a serial number. This is made up of a combination of 37 digits and letters, which you will have to enter without any spaces in between, but including the special characters (hyphens).

You will find the serial number either on the CD case or on the invoice. Alternatively, if you made your purchase online, you will have been notified by e-mail.

1.2.2 ProgrammeID

The programme ID is allocated specifically for your computer and is only valid for use on your computer. A valid serial number, issued on purchase of the programme, is required to obtain an ID.

The programme ID is automatically provided as soon as you enter the serial number.

It is not possible to enter the programme ID yourself.

You will need to let us know the programme ID when registering, so that we can send you your key code.

1.2.3 Registration

You can activate your programme in three different ways.

Request a Key Code Online

This method requires that your computer has internet access.

Click on the “Online” button to open a form, where you can enter all the information required to receive a key code. The fields marked with an * must be completed.

After you have completed the form, you can send it straight off – the recipient’s e-mail address is entered automatically for your convenience. After sending the e-mail, you will receive your key code, which will be sent to the e-mail address you have entered, in approximately 20 minutes.

Request a Key Code by Fax

If you click on the “Fax” button underneath the Programme ID section in the registration dialogue, a form opens that you can complete and print off. After you have completed the form, it should be sent to the fax number: +49 (0)30 588 439 11.

You will receive the key code within one working day. You can also provide an e-mail address, so that we can send you the code by e-mail. As the key code is entered by hand, you can also receive the e-mail notification via another computer.

Request a Key Code by Telephone

If you do not have a fax or e-mail, you can request the key code by phone. In this case, you will need to give us your programme ID when you call.

1.2.4 Activating

Once you have completed registration, you will receive your key code within the following period:

- Approx. 20 minutes after online registration
- 1 working day after fax registration.

You can close the programme in the meantime. When you go back into the programme to continue registration, the entries you have made so far have been saved. Once you have received the key code following Registration, you should enter it into the key code input field. When you click on “OK” you will receive a message to confirm that your programme has been activated.

You can now start working with the full programme without having to start up again.

We are pleased to support your work and wish you every success!

1.2.5 Licence Agreement

STANDARD SOFTWARE AGREEMENT

between the user

and

the company

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D-10243 Berlin, Germany

in the following referred to as the "supplier".

§ 1 Object of Agreement

1. The object of agreement is an item of the present software, consisting of the copy of the computer programme (programme for MS-WINDOWS®) on the data carrier in object code.

§ 2 Computer Programme Right of Use

1. The supplier provides the user with the non-exclusive, permanent, revocable on agreement of both parties only, transferable right of use for the computer programme.

2. The right of use authorizes the user to single use of the computer programme within the scope of normal usage in a software environment that corresponds to an MS-WINDOWS'® operating system. The right of use does not extend to other types of use.

3. Normal use includes as permissible actions:

a) programme installation

b) loading the programme onto the main memory and its running in accordance with § 4,

c) necessary actions within the scope of error correction in accordance with § 5.

4. Outside of these actions the user is not permitted, due to copyright laws, to make any changes, translations or copies of the computer programme whatsoever, also not to any part of the programme or temporarily, regardless of what type and with which means. Inadmissible duplication also constitutes the printing of the programme code. Changes for which, acting in good faith, consent cannot be withheld are admissible.

§ 3 Installation and Activation

1. The user is authorized to transfer as many functioning copies as required from the original data carrier onto a computer memory, as long as the working programme is used in its limited form as a demo programme.

2. The user is authorized, with the assistance of a serial number, to activate the same number of installed copies of the programme as the number of licences that have been purchased. (A single licence refers to single programme activation.)

3. If the user's authorized copy of the activated programme is damaged or a replacement programme is required, a replacement copy of the programme may be activated.

§ 4 Loading and Running the Programme

1. The user is authorized to load and run the computer programme on the main memory of a computer. In addition, it is not permitted at any time that more than one copy of the programme be available for use on the main memory (single use).

2. This also and particularly applies in the case of the use of a computer network. Parallel multiple-use within a network should be prevented by access protection mechanisms.

3. The user acquires the right to use the software on as many workstations connected to a local area network as the number of licences the user has paid for (multiple-licences). The basis for assessment is the number of licences listed on the corresponding invoice and, if appropriate, any special arrangements made (multiple-licence price rates, unlimited licences, etc.). Computers used for work purposes at home belonging to the network, portable computers temporarily connected to the network and remote computers also count as workstations within the network. If these simply serve as a replacement for the workstations connected to the local area network, an additional workstation licence is not required. If the agreed number is exceeded, error-free operation cannot be guaranteed. The use of the software on portable computers also counts as simultaneous operation.

§ 5 Error Correction

1. The user is authorized to correct errors in the computer programme and in this regard make necessary changes and duplicates. An error authorized for correction only occurs if:

a) the programme features deviate from the programme description within the user documentation or the programme does not fulfil its objective designated function and

b) in addition the running of the programme is not only insignificantly disrupted.

2. The supplier should be informed if such an error occurs. He will endeavour without having any legal duty in this regard to support the user. If the supplier corrects the error within a reasonable period this will make any error correction on the part of the user inadmissible.

3. The user is not authorized to make any amendments other than error correction.

4. No right exists to the reimbursement of error correction costs.

5. The user's rights of guarantee remain unaffected by this provision.

§ 6 Limits of Use

1. The user is authorized to use the computer programme on any hardware and with any software, as long as the system environment corresponds to an MS-WINDOWS'® operating system.

2. Removal (transmission, transfer, migration) onto other system environments is not allowed unless the manufacturer, in good faith, has to agree to a change in the programme.

§ 7 Passing On or Renting To a Third Party

1. The user is only authorized to pass on the software in its complete form, as delivered to the user, i.e. the data carrier with the user documentation, and only if the computer programme right of use is passed on at the same time. This is on the condition that the party taking possession of the computer programme declares themselves in agreement with the terms of the agreement contained in §§ 2 to 8.

2. The user is not authorized to transfer the programme by re-recording it in any form.

3. If the user passes on the programme all duplications must be fully and irreversibly destroyed.

4. The user must immediately inform the supplier that the programme has been passed on and provide him with contact details for the new licence holder.

5. The user is prohibited from renting to a third party, i.e. passing the programme on for a short time for a fee.

§ 8 Guarantee

1. If the software is faulty the user can demand, according to choice, replacement of the programme or cancellation of the sales agreement. No right to the removal of the defect exists.

2. The user must inform the supplier of any obvious defect in writing within two weeks of delivery. If this deadline is missed guarantee rights due to the defect concerned are excluded.

§ 9 Liability

1. The supplier has unlimited liability according to legal regulations for the promised features and in the case of gross negligence or intent.

2. In the case of simple negligence liability is excluded, insofar as neither a basic duty of contract (cardinal duty) is violated, nor life or limb injured, or a case of delay or impossibility is presented.

3. The user is aware that, within the scope of his/her duty to keep damage at a minimum, he/she should ensure that in particular regular backups of his/her data are carried out and in the case of a suspected software error all reasonable additional security measures must be taken.

§ 10 General Terms and Conditions

1. The General Terms and Conditions of Valentin EnergieSoftware GmbH apply.

2. The actual status of the General Terms and Conditions can be found at http://www.valentin.de/index_en_page=agb.

Status 2009/1: 16.11.2009

1.3 Main Screen (menus, button bar, dialogue windows)

The PV*SOL® programme is simple to use with the usual WINDOWS™ menu bar and Speed Buttons. You will find the individual menu commands listed and explained under Menu.

A menu command is deactivated when the lettering changes from black to grey. For example the command Calculations/Simulation is deactivated when valid simulation results are available. This command is reactivated only when the simulation results are no longer valid.

All of the dialogue windows required for inputting simulation parameters or to display results can be activated by clicking on the appropriate menu command, by using a combination of the ALT key plus the letter underlined in the menu command, or by clicking on the appropriate speed button symbol in the button bar on the left-hand side of the main screen.

The dialogue is closed by clicking on **OK**, **Cancel** or **Close**, by clicking on the WINDOWS button marked with an X in the top right-hand corner of the dialogue, or by the key combination *ALT+F4*.

The dialogue windows consist of input fields (editing fields), selection fields (check boxes), selection lists and buttons.

You can use either the mouse or the tab key to move between the fields within a dialogue window. With the *TAB* key you move to the next field and with *SHIFT+TAB* back to the previous field.

The various values are keyed into the input fields. When the arrow points over an input field it automatically changes to a cursor. With a single click of the left-hand mouse button in the input field you are ready to enter text with the keyboard. By double clicking on the input field the entire text within the field is marked and will be deleted as soon as you start to type.

The formats for numbering, date and currency are as per the settings within the WINDOWS system control panel. If you change the settings in the system control panel you will have to restart PV*SOL® in order to activate the changes within the programme.

On quitting a dialogue window with **OK,** the programme checks whether valid formats have been used and at the same time tests if the entered values are within reasonable limits.

In addition to the input fields, the programme uses selection fields (check boxes). These are small square or circular fields that are activated or deactivated with a single click of the mouse. If the selection fields are grouped together, only one selection is possible.

By clicking on the buttons in the dialogue window you can open further dialogues. The buttons in the left or bottom button bar of a window (eg OK, Cancel, Copy, Close) control the window.

1.4 Project Design

In order to reduce the number of parameters to be entered and to make it possible to quickly become familiar with the programme, projects designed with PV*SOL® are made up of individual components.

These components are loaded as files from the comprehensive database that comes with the full programme. This means that you simply have to load the individual Components from the files provided.

With more experience in using the programme, user-defined data can be added to the units in the Database menu. The components cannot be added to or amended directly from within a project – you have to go to the appropriate Database unit.

One exception, however, is the tariff for supplying energy to the grid. The To Grid Tariff can be entered from a number of positions within the programme. At the menu command Conditions/Tariffs you are able to load and define a tariff. And under Calculations/ Economic Efficiency Calculation... you are also able to set a tariff for exporting energy to the grid. It therefore isn't absolutely necessary to enter this tariff via the database.

For all other database units PV*SOL® monitors whether:

1. changes have been made to the data contained in the files loaded into the project you are currently working on,

2. the files loaded into the project you are currently working on still exist,

3. a dialogue used for loading files from the database has been closed without first loading a file.

If so, a corresponding Message will appear.

To disable this facility you should select "No monitoring of project components" in the Options/Paths... dialogue window.

Components are loaded by selecting a file reference in the standard "Load File" dialogue. For PV modules and inverters there are special dialogues for loading files because of the large amount of data held. This means that files can be sorted according to different criteria to make it easy to select the desired module or inverter type.

If you have installed the programme correctly, the "Load File" dialogue appears and you are able to make an immediate selection from the files provided.

If the path setting within this dialogue does not match your standard settings, you are able to change the path settings under Options/Paths... From here you can also select whether a new project (Quick Design) or the last project you worked on should appear on screen each time you start up the programme.

1.5 PV*SOL® Components

The PV*SOL® components are:

- PV modules
- Inverters for grid connected and stand-alone systems
- Batteries
- MPP trackers
- Load profiles for electrical load
- Electrical appliances
- Weather data for the system site
- Tariffs for energy supplied to and drawn from the grid
- Pollutant mix for electricity from the grid and energy savings.
- Loans

The individual components are defined via the corresponding Menu or the Speed Buttons.

1.6 Load and Save File

Projects, components, tariffs and appliance profiles are saved to file or loaded from this dialogue.

Each file type has its own format and a set file extension. These are:

.prj	for Projects
.wbv	for weather data
.emm	for the pollutant mix
.tar	for the from grid tariff
.eta	for the to grid tariff
.slg	for loads
.mod	for PV modules
.wrn	for inverters (grid connected)
.wra	for inverters (stand-alone)
.sch	for shading
.vbi	for individual appliances
.mpp	for MPP trackers
.acc	for Batteries
.cre	for Loans

From this dialogue you can **Select** files from those available in the list.

When you **Open** the dialogue the directory that has been entered under the Options/Drives menu is displayed. If you want to select another directory as standard, you will have to do this in the **Drives** dialogue.

When a file from the file dialogue is **selected** a description of the file contents appears in the field labelled ”File Reference”.

You are able to exit the dialogue with **OK** only after you have selected or entered a name in the ”File Name” field. Click on the **OK** button to load the selected project.

When you **Save** an existing file the project automatically checks if you want to go ahead and overwrite the file.

The load file dialogue for **Modules** and **Inverters** is different from the other standard dialogues. In addition to the file name, details on the contents of the files, ie manufacturer, type, output and voltage, are displayed. These details can be sorted by heading. Any new order selected will remain unchanged regardless from where the dialogue is next opened. If you have already selected a type of module or inverter, this data record will be highlighted in blue.

1.7 Simulation

Starts simulation of the current project with the given parameters. The system is simulated at hourly intervals over a year.

The basis for the calculations can be found in the programme user manual.

The simulation only takes a few seconds, although the exact time depends on the computer being used, the number of arrays in a system and the type of temperature model selected.

After simulation you can select whether you want to run the Economic Efficiency Calculation, or view the Annual Energy Balance, the Summary Project Report, or the Graph of Results.

You are also able to go back to the programme's main screen and continue work on your project using the menu bar or speed buttons.

All results are now activated in the Results menu and can be viewed. As long as the project parameters remain unchanged you are not able to carry out the **Calculations/Simulation** command.

1.8 Speed Buttons on the Main Screen

At the top of the main screen is a button bar with a number of speed buttons, each with a different icon. These icons represent the menu commands that you will use most frequently when working with the programme. Clicking on the various speed buttons is the quickest and easiest way to get to the most important dialogues.

Each speed button is labelled with its menu title. You just have to position the pointer over the button icon and a label appears with the title.

New Project

Open...

Save

Technical Data (only systems without 3D Visualisation)

3D Visualisation (only systems with 3D Visualisation)

Weather Files

Tariffs

Individual Appliances

Appliances – Load Profile

Shade (only systems without 3D Visualisation)

Simulation

Economic Efficiency Calculation...

Annual Energy Balance

Energy and Weather Data...

Summary Project Report

Variant Comparison...

1.9 Definitions

Array – see PV Array.

Back-up Generator – Direct Energy Use

If a back-up generator is specified in the system configuration, the energy generated by the back-up generator and the energy used directly by the appliances is identified. With direct current appliances, the alternating current is converted to direct current by the battery charger.

Back-up Generator - Energy

The energy generated by the back-up generator includes direct energy consumption and the energy used to charge the battery.

Back-up Generator – Fuel Consumption

If a back-up generator is used, the annual fuel requirement needs to be specified. The fuel consumption is calculated from the energy generated by the back-up generator and the specific fuel requirement entered.

Battery - Charge

The total energy going into the battery (or the batteries) is shown. If the system is simulated without a back-up generator, this corresponds to the solar energy charge.

Battery –Charge, Solar

For systems with a back-up generator, the portion of the charge that comes from solar energy is given separately. The difference from the total charge comes from the back-up generator's portion.

Battery – Charge Condition

The battery's charge condition at the start of simulation can be defined in the system configuration (default = 30%)

Battery – Content, Back-up Generator (After Simulation)

This value appears only when a back-up generator is used. It describes the proportion of energy produced by the back-up generator that is available in the battery at the end of the simulation period.

Battery – Content, Solar (After Simulation)

The proportion of solar energy available in the battery at the end of the simulation period is given.

Battery - Discharge

The total energy from the battery (or the batteries) is shown. If the system is simulated without a back-up generator, this corresponds to the discharge of solar energy.

Battery – Discharge, Solar

For systems with a back-up generator, the proportion of discharge that is based on solar energy is given separately. The difference from the total discharge comes from the back-up generator's portion.

Battery - Losses

Battery losses come from the battery efficiencies during charge and discharge, and self-discharge.

Battery - Performance Ratio

The battery's performance ratio is the relationship between discharge and charge.

Charge Condition at Simulation Start/End

The battery's charge condition at the start of simulation (defined in the system configuration) and the calculated charge condition at the end of simulation is shown.

Consumption - Requirement

The requirement is the sum of the annual energy requirement of all defined Appliances.

If no appliances have been defined, this value is not given. You are also able to define appliances if the ”Full Supply” to grid concept has been selected.

Consumption – Covered by Solar Energy

The consumption covered by solar energy is made up of direct energy use and the solar portion of the battery charge.

Consumption – Not Covered

The consumption requirement that cannot be covered by the system is shown as the amount of energy required that cannot be provided either by the PV array or by the battery.

Energy Converter

This dimension is only shown if MPP tracking is going to be used. The losses that occur when using an MPP tracker are subtracted from the generated energy.

Energy Requirement - Covered by PV Generator

This dimension is only given when the ”Own Use” concept is selected. It is the energy generated by the solar system that is used to cover the energy requirement of the appliances.

External Temperature

The external temperature is a specification taken from the weather files. It is required to define the module temperature, as the module efficiency is dependent on the temperature (see PV Module).

Generated Solar Energy (Alternating Current Side)

The generated solar energy (AC side) is the energy after conversion of the PV direct current into alternating current, which can either be fed into the grid or used to cover the load requirement. The energy used by the inverter itself is not taken into account.

Generated Solar Energy (Direct Current Side)

When designing a PV system, the energy that is produced by the PV modules is also of interest, ie the energy flow before entry into inverter.

Grid, Electricity From

If all the energy produced by the PV system is fed into the grid, the total load requirement and the inverter’s own consumption will have to be covered by electricity drawn from the grid. If the ”Own Use” concept is selected, the energy drawn from the grid is reduced by the proportion of PV generated energy that is used to cover the load requirement.

Grid, Electricity To

If the ”Full Supply” to grid concept is selected (see Tariffs), all solar energy generated is fed into the grid and this dimension is not given. If the ”Own Use” concept is selected, only the proportion of energy that is not used by the appliances is exported to the grid.

Inverter Efficiency

The inverter efficiency is the energy generated on the alternating current side in relation to the energy fed into the direct current side.

The efficiency is made up of the Inverter Characteristic Curve, the MPP adjustment efficiencies (see Inverter Database) and the inverter’s own consumption.

A very poor inverter efficiency (in comparison to maximum efficiency) is above all possible if the inverter is oversized or because its maximum nominal output limits the PV power output.

Irradiation onto Tilted Array Surface

The irradiation onto the tilted Array surface is the energy (after subtraction of shade) on the PV surface that is available for conversion. A proportion of this energy is lost through reflection on the module’s surface.

Module Temperature

There are two different Temperature Models in the programme. Module temperature definition is dependent on the weather data, module specific parameters and the type of mount. The module temperature for each array is given on each array worksheet.

Own Consumption - PV System

The PV system's own consumption comes from the energy used by the inverter, when no PV energy is being produced. During the day, the inverter draws on the grid for its stand-by consumption. At night, if the inverter is not switched off completely, it also draws energy for night consumption. Both dimensions are entered in the characteristics for the Inverter.

Performance Ratio

The performance ratio is a measurement of the energy losses within the system that occur in comparison with the system's nominal output. The nominal output is calculated from the irradiation onto the tilted PV surface multiplied by the module efficiency under standard test conditions (25 C, 1000W/m²).

PV Array – Direct Energy Use

Direct energy use means the energy that flows direct (without being stored before use) to the appliances. With alternating current appliances, however, the energy will have to be converted to AC by the stand-alone system inverter, before it can be used to cover electricity consumption.

PV Array – Energy Surplus

An energy surplus occurs if the solar energy available is not required by the appliances and the battery is charged.

PV Array – Generated Energy

The generated energy is the energy exiting the PV generator. Losses through MPP tracking are not accounted for. These dimensions also include any PV array surplus that may occur.

PV Array - Irradiation

The irradiation onto the tilted PV array surface is the solar energy that remains available after subtraction of shade. A proportion of this energy is lost through module surface reflection.

PV Array - Efficiency

The PV efficiency is the DC energy produced in relation to the total energy irradiated onto the array surface. Here the inverter's efficiency and the cabling losses are not taken into account, as they are during the system efficiency calculation.

The array efficiency takes the following into account:

- the reflection losses at the module surface,
- the PV module's efficiency, ie the characteristic curve for the PV module and the temperature coefficient for PV output (see PV Module database), and
- the array's Additional Losses.

PV Array - Radiation

The programme uses a radiation processor to convert horizontal radiation into radiation onto the tilted surface using the following dimensions: the degree of latitude, the angle of inclination, the azimuth and the albedo.

Radiation Minus Reflection

Part of the radiation onto the PV surface is lost due to reflection losses on the module surface. The direct radiation is reduced by the module incident angle modifier (see also: PV Module)

Radiation onto the Horizontal

The horizontal radiation is taken from the Weather Files.

Radiation Without Shade

If the array is shaded for a period, the radiation that would fall onto the tilted PV surface if the surface was not shaded is identified.

Solar Coverage Proportion (Grid Connected)

The proportion of solar coverage is the generated energy (after subtraction of the inverter's own consumption) in relation to the load requirement. It is only of interest for the "Own Use" concept (see Tariffs) and is only given if an electrical appliance is defined. The solar coverage proportion does not express how much of the generated energy can be used in direct load coverage.

Solar Coverage Proportion (Stand-Alone)

The proportion of solar coverage is the relationship of the consumption covered by solar energy and the energy requirement. The consumption covered by solar energy comes from direct energy use and the solar portion of the battery charge.

Specific Annual Yield

The specific annual yield is an evaluation dimension that gives the system's annual yield standardised to the installed output. In other words, the specific annual yield corresponds to the system's peak load operating hours.

Another well known evaluation dimension is calculated from the specific annual yield: the final yield. The final yield is the specific annual yield divided by 365 days.

System Efficiency

The system efficiency is the quotient from the usable solar energy from the PV system and the total energy irradiated onto the generator surface. It is made up of the PV array efficiency, the inverter efficiency and the cabling losses.

Wind Speed at a Height of 10m

The wind speed is accounted for when defining the module temperature in the dynamic Temperature model. In the weather files provided the wind speed is measured at a height of 10 metres.

2 Menu

2.1 Menu

The menu is used to open the various dialogues which are used to enter the project parameters. Under each main menu heading is a list of menu commands.

You can also quickly access the most important commands by clicking on the Speed Buttons in the button bar on the main screen.

If you want access the menu commands without using the mouse you can do so by pressing the Alt key and the corresponding underlined letter in the menu command.

File

Conditions

Appliances

System

Calculations

Results

Database

Language

Options

Help

2.2 File Menu

2.2.1 File Menu

Here you will find all of the commands you will need for organising project files and you can exit the programme via **Exit**.

New Project

Project Administration...

Open...

Save/Save As...

Exit

2.2.2 New Project

This dialogue window appears automatically when you start up PV*SOL. From here you can start defining a new project.

First of all you have to decide whether you want to simulate a grid connected or a stand-alone PV system (not available with PV*SOL®-N for grid connected systems only).

If you answer ”Yes” to the question ”Do you want to start a new project with Quick Design?” the Quick Design screen will open. In this case the files stndrd1.prj (grid connected) or stndrd2.prj (stand-alone) will be used to provide standard values.

If the corresponding field is grey and cannot be selected, it means that the standard file has possibly been deleted. If so, you can copy these files from the project folder

(eg. c:\pvsol\projects\…) or rename an existing file from within Explorer.

If you already have a project open prior to starting up a new project, a prompt will open asking you if you want to save the project that is open before the Quick Design screen opens. On leaving the New Project screen the main screen background changes according to the type of system you have selected.

If you opt for starting a new project with Quick Design, the

Quick Design dialogue opens. From here you can simulate a solar system very quickly.

The dialogue windows vary according to the type of PV system – grid connected or stand-alone.

Quick Design – Grid Connected Systems

Quick Design – Stand-Alone Systems

2.2.3 Project Administration...

In Project Administration you can enter the project name, the project number, the project designer and the location of the PV system.

For easy project identification, these details will appear on any printouts that you make.

From the main screen you can also enter a system variant reference. This appears as a file reference with the project file name.

Whenever you exit a project with the command **File/Save As…**, the project administration details are saved with the project.

With the command **File/Save As...** you can therefore save as many versions of a project as you wish, and they are easily recognisable by the comment you enter in the variant reference field.

2.2.4 Open...

File/Open... opens the Open File dialogue, where all projects are listed – ie all files with the file ending *.prj.

Select a file and the system variant reference appears in the file reference field.

Double clicking on the file name, or clicking on the **OK** button, opens the selected project.

If you are working on a project, and at the same time open another project, a message will appear asking if you want to save any changes made to the project you were originally working on, which will then close to enable you to work on the project you have opened.

The other way to open existing projects is to go to the **File** menu. At the bottom of the menu is a list of the projects you have previously worked on, the first on the list being the project currently open. Just double click on any of the project file names to open the file.

2.2.5 Save or Save As...

File/Save saves the current project to the valid file path and name as previously saved. If a project file does not yet exist (ie you are saving a project for the first time), the **Save As...** dialogue appears.

File/Save As... saves the current project under a new name of your choice. The system variant reference is automatically selected as the file reference.

This command is used when you want to design a new project or design a new version of a project.

You should create a separate folder for each project, into which you can then save all the different versions of a project.

2.2.6 Exit

Go to **File/Exit** to close the programme.

If you have not yet saved the changes you have made to the current project, a message will appear asking if it should be saved.

If you wish you can change the programme settings, so that the last project you have worked on automatically opens the next time you use PV*SOL (instead of the Quick Design dialogue), this is done via **Options/Paths**.

2.3 Appliances Menu

2.3.1 Appliances Menu

There are two ways of setting the electricity requirement.

If you are able to give a figure for the total annual energy consumption, you should enter this value in the load profile dialogue. If not, you can enter values for a range of individual electrical appliances.

If you use both of the above methods, the programme calculates the total requirement. If, for example, you have entered values in the load profile dialogue, the energy requirement is shown when you open the individual appliances dialogue, and is then included in the calculation of the total energy requirement.

When designing a stand-alone system you will need to select either AC or DC appliances in the System/Technical Data menu.

Load Profile

Individual Appliances

2.3.2 Individual Appliances - Consumption

In this dialogue you are able to define the energy requirement for up to 20 individual appliances.

Click on the **New** button to define parameters for a new appliance. The following actions apply to the individual appliance you have selected. Click on the name (not the symbol) of the appliance to select it (this will then be marked blue).

Click on the **Load** button to load preset parameters from the database for the appliance selected. Click on the **Delete** button to delete the appliance selected.

Click on the button with the appliance's symbol to open the Individual Appliance dialogue.

2.3.3 Kilowatt-Hour Price

The price per kilowatt-hour for each tariff period - high tariff (HT), low tariff (LT) and any special tariff (ST) - is defined in this dialogue. In order to be able to define the tariffs for special periods, these have to be entered under **Tariff Time Periods**.

Price Change Factor:

The rates that need to be entered into the table are basic prices that produce the kilowatt-hour rate when multiplied by the price change factor. With the price change factor the grid utility company takes the current energy price and eg. wage increases into account. Normally, only the basic price level is used in the low voltage range, so that the price change factor is 1 in this case.

Summer/Winter Different:

Different kilowatt-hour rates can be entered for summer and winter times. In this case the prices are not valid for the whole year's energy consumption, but for summer and winter periods. If at the same time **Different Pricing Bands for Each Tariff Period** is selected you can separate out the kilowatt-hour rates for summer and winter periods into high and low tariffs.

Staggered Consumption Regulation:

If this selection is made the valid kilowatt-hour price is given as follows:

- With a total annual consumption during HT periods of 600,000 kWh, for example, the price band starting from a consumption level larger than 500,000 kWh is valid, for the total energy produced during the HT period HT energy the basic price of 0.35 €/kWh is valid.

Consumption Zone Regulation:

On making this selection the text of the first column changes in order to make the prices given clearer. "Consumption larger than" becomes "Each further kWh from". The valid kilowatt-hour rate is given as follows:

- With a total annual consumption during HT periods of 600,000 kWh, for example, a basic price of 0.36 €/kWh for the first 250,000 kWh is valid, for the second 250,000 kWh the basic price of 0.35 €/kWh is valid and for the final 100,000 kWh a basic price of 0.33 €/kWh is valid.

The total HT kilowatt-hour rate is therefore calculated as follows:

Total HT kilowatt-hour rate : (250.000 kWh * 0.36 €/kWh + 250.000 kWh * 0.35 €/kWh + 100.000 kWh * 0.33 €/kWh) * Price change factor

Different Pricing Bands for Each Tariff Time Period:

On making this selection the kilowatt-hour rate for each tariff period is given its own worksheet. In this case the valid pricing band is no longer given as the total annual consumption, but as the total consumption in the time period that is valid for each worksheet. If, for example, **Summer/Winter Different** is not selected, then the valid kilowatt-hour rate for the winter HT is only given in the total consumption for summer and winter HT.

See also: From Grid Tariff

2.3.4 Load Utilisation Period Discount by Table

Instead of a linear climbing load utilisation period discount (see Discounts), it is also possible to account for price bands in a table. The discount table values can be entered in the Load Utilisation Period Discount dialogue. Here it is also the case that a Load Utilisation Period Discount is first observed when the minimum load utilisation period is reached.

See also:

From Grid Tariff

2.3.5 Individual Appliances: Short-Time Use Appliance

A short-time use appliance is a user-dependent appliance that is generally switched on for less than an hour each time it is used, eg iron, coffee maker.

Stand-by: an entry here is only made for appliances with this facility where stand-by is always active when the appliance is not in operation.

Operating Times – Each Time Appliance Used: entry of either the period of use or the electricity requirement.

Hourly Use: entry in the bar showing the hours of the day. If the tick is removed it is possible to enter hourly use separately for each day of the week.

Individual Appliances

2.3.6 Power Measurement

The basic specifications for power measurement are entered in this dialogue. Further specifications can be made depending on the type of power measurement selected. The following power measurement categories are available:

No Power Measurement

96 Hour Measurement

Standard Calculation (¼ hour power measurement)

Light/Heavy Load Maximums

No Power Measurement

If the tariff for energy supply from the grid suffices without power measurement, then you should select ”No Power Measurement”**.**

96 Hour Measurement

With the 96 hour tariff the electricity consumption in kWh within 96 consecutive hours is added together in a consecutive time window. These hourly values are called power values (Pow. Val.). The highest power value within the time period measured is used for the calculation of power payment. The power payment is the sum of the highest power value multiplied by the valid load price for annual electricity consumption according to the given pricing band.

During 96 hour measurement with time zone regulation, the recording of the power values during low tariff is suspended without changing the consecutive timing for the 96 hour measurement periods. In this case **Measurement Only During HT Periods** must be selected in the Load Price dialogue

Standard Calculation (¼ hour power measurement)

This calculates the power from the average value of the highest monthly power output figures. The number of months that are used to calculate the maximum annual power output is entered in the Load Price dialogue.

Light/Heavy Load Maximums

¼ hour power measurement, with the time period used for providing the billing load being limited to the so called heavy load periods. These heavy load periods are entered in the Heavy Load Periods dialogue. Further definition of the heavy load peak is described under **Standard Calculation**.

The lowest monthly light load is entered separately.

Output peaks during low output periods are only considered if the monthly low output peak reaches a level above the given annual peak power output at peak load times. The monthly differences of these values are sorted according to size and an average value is calculated. The resulting difference is only partly used in the calculation, the factor is entered in the Load Price dialogue. The number of months used for producing a figure for the light load peak is also entered in the Load Price dialogue. The sum of the heavy load maximum and the allowed for light load share gives a figure for the calculated power.

Set Load Price:

The electricity payment is made up of two parts: a set price and a price dependent on consumption. The set load price must always be paid separately from the price for grid power actually used.

Hourly Peaks in the Defined Load Plus:

(only for **Standard Calculation** and **Heavy/Light Load Maximums**)

Depending on the grid utility company, monthly power outputs are measured in ¼ or ½ hour averages. The highest output during the year is multiplied with the given specific load price, in order to give a figure for the annual load price that will have to be paid. In the programme the highest monthly output figure is the highest occurring average hourly output in each month (to account for the time stages). This leads to lower output peaks because the ¼ hour variations are levelled out. In order to correct this the highest monthly outputs for calculating the highest annual output are multiplied by the ¼ hour peaks in the defined loads plus. Depending on the type of appliance, the size of the area supplied, and any measured loads to hand, a percentage figure between 0% and 50% must be entered here. For typical housing estates with an annual consumption of more than 100,000 kWh, an annual consumption of 5-10% can be used for the calculation.

Minimum Power Output:

(only for **Standard Calculation** and **Heavy/Light Load Maximums**)

This measure is only used in the calculation if the maximum output is less than this value.

Wholesale Provision:

(only for **Standard Calculation** and **Heavy/Light Load Maximums**)

Instead of a set load price, a price for wholesale provision can be requested. This is paid if the hours of full use (HFU) do not reach the set threshold value. The wholesale provision price (WPP) is calculated as follows:

WPP = price [€/kW] * max. power output

* (1 HFU/hours of minimum use)

Max. power output: the maximum power output calculated by the programme, or possibly the minimum output.

HFU:

Hours of full use = total annual kWh output/maximum output

See also:

From Grid Tariff

2.3.7 Load Price

This dialogue is used to define the demand price for the electricity tariff. Different entry fields are activated depending on what form of power measurement is selected, so that additional specifications can be entered.

Number of Maximums Allowed For

(only for Standard Calculation and Heavy/Light Load Maximums in the Power Measurement dialogue)

Heavy Load:

The number of monthly maximums is entered here. The heavy load peak is calculated from the average of these monthly maximums. With the standard calculation the heavy load peak corresponds to the billing load.

Light Load:

(only for Heavy/Light Load Maximums in the Power Measurement dialogue)

With power measurement using Heavy/Light Load Maximums, light load maximums are considered under certain conditions. Here the number of monthly maximums is entered, from which the light load peak is calculated.

Include Light Load Maximums:

(only for Heavy/Light Load Maximums in the Power Measurement dialogue)

This factor describes which percentage of light load additional output is included in the billing load calculation.

Price Change Factor:

The prices to be entered in this table are base prices that, multiplied with the price change factor, give the load price per KW. With the price change factor the grid utility company takes the current energy price and eg. wage increases into account. Normally, only the basic price level is used in the low voltage range, so that in this case the price change factor is 1.

Pricing by Total kWh:

Instead of giving price bands or price zones for the load price via the billing load, in this case the load price is given by annual electricity consumption in kWh.

Staggered Consumption Regulation:

see Kilowatt-Hour Price

Consumption Zone Regulation:

see Kilowatt-Hour Price

Measurement Only During HT Periods:

(only for 96 hour measurement in the Power Measurement dialogue)

Corresponds to 96 hour measurement with time zone regulation. Here the output values during low tariff periods are not included, without changing the 96 hour measurement periods' progressive intervals.

See also: From Grid Tariff

2.3.8 Individual Appliance: Light

An appliance is defined as a light when it is switched on depending on the amount of daylight.

Stand-by: an entry here is only made for appliances with this facility where stand-by is always active when the appliance is not in operation.

Operating Times:

All days the same: if the tick is removed, it is possible to enter different operating times for all the days of the week.

Clock: the hours of operation are set by clicking on the fields (green field = in operation, white field = not in operation). The appliance can only operate within the defined operating hours.

No Other Restriction: the operating times are as defined by the clock.

Full Darkness: the operating hours are only valid if, at the same time, global radiation equals zero. .

Dusk: the operating hours are only valid if, at the same time, global radiation is less than 20 W/m².

Dull Weather: the operating hours are only valid if, at the same time, global radiation is less than 50 W/m².

Individual Appliances

2.3.9 Individual Appliances: User-Dependent Appliance

A user-dependent appliance is used regularly and at certain times, eg TV, computer.

Stand-by: an entry here is only made for appliances with this facility where stand-by is always active when the appliance is not in operation.

Operating Times:

All days the same: if the tick is removed, it is possible to enter different operating times for all the days of the week.

Clock: the hours of operation are set by clicking on the fields (green field = in operation, white field = not in operation).

No Other Restriction: the operating times are as defined by the clock.

Nights Only: the operating hours are only valid if, at the same time, global radiation equals zero. .

Days Only: the operating hours are only valid if, at the same time, global radiation is greater than zero.

Individual Appliances

2.3.10 Individual Appliances: User-Independent Appliance

A user-independent appliance is not normally switched on and off by the user, but runs automatically for long periods of time – eg refrigerator, deep-freeze.

Stand-by: an entry is not possible in the case of an appliance in constant use.

Annual Energy Requirement: the annual energy requirement should be given for general operation over the whole year.

Operating Times: the appliance can either be defined as being in constant use or by the intervals it remains switched on.

Appliance in Constant Use: the appliance is generally switched on the whole time.

Switch on Every…: sets the switching-on interval.

Individual Appliances

2.3.11 Discounts

General Discount:

Here you can enter rebates/discounts that are guaranteed regardless of consumption, eg a discount for electricity drawn at the 30 kV voltage level.

Load Utilisation Period Discount:

(only for Standard Calculation and Heavy/Light Load Maximums in the Power Measurement dialogue)

The load utilisation period is the relationship of total annual energy drawn from the grid to the billing load, and is a measurement of the regularity of energy use. With some tariffs or special deals the electricity company gives the customer a discount from a point over a certain minimum load utilisation period. This discount is, as a rule, included in the total kilowatt-hour and load tariff payments. In the case that the discount is only observed for HT energy and the load price, it is referred to as the HT utilisation period rebate.

Minimum Load Utilisation Period:

A discount is first included in the calculation when the load utilisation period is above this figure. If the usage is below this figure, an additional charge does not have to be made in compensation.

Load Utilisation Period Discount Valid for:

Here you can select the payment categories for which the load utilisation period discount are valid for.

Load Utilisation Period Discount by Formula:

If this option is selected the load utilisation period discount is calculated using the following formula:

> if the load utilisation period – minimum load utilisation period > 0 load utilisation period discount = Factor X * (load utilisation period – minimum load utilisation period)

Load Utilisation Period:

The relationship of total annual energy drawn from the grid to the billing load.

If the calculated load utilisation period discount exceeds the maximum load utilisation period discount, this figure (ie the greater) is observed.

Load Utilisation Period Discount by Table:

Instead of a linear climbing load utilisation period discount, it is also possible to account for price bands in a table. The discount table values can be entered in the Load Utilisation Period Discount dialogue. Here it is also the case that a load utilisation period discount is first observed when the minimum load utilisation period is reached.

See also:

Supplements

From Grid Tariff

2.3.12 Heavy Load Periods

The heavy load periods for the grid are defined in this dialogue.

Heavy Load Periods - Summer/Winter Different:

If you click on this button you are able to enter all the heavy load periods separately for summer and winter.

Heavy Load Periods – From… To:

If the heavy load periods for summer and winter are different, this is where you define the beginning and end of winter time for the heavy load periods. Entry of heavy load periods is made in date format dd.mm. .

New Heavy Load Periods Valid From:

With the assistance of this field you are able to define the days in the week that heavy load periods are valid on. The days of the week are given in the first column, so that it is clear for which day the time entered is valid.

Heavy Load Periods:

You are able to enter up to 5 time periods (from hour to hour) for each day of the week. Entry is made in time format.

See also:

From Grid Tariff

2.3.13 Discounts/Supplements

You can enter Discounts and Supplements from the electricity utility separately on the two pages provided.

See also:

From Grid Tariff

2.3.14 Electrical Appliances by Load Profile

The electrical energy requirement for an appliance load is defined in the **Electrical Appliances** dialogue. For ease of identification this can be given a **Name**.

The **Annual Energy Consumption** for the appliance load is entered directly (in kWh).

The hourly pattern of consumption is set via a consumption profile. The consumption on Saturdays and Sundays is entered as a percentage of the weekday usage.

The required consumption profile can only be loaded from this dialogue, not defined. Click on the **Consumption Profile** button to open the Load File dialogue.

If you want to define your own load profile, you have to go to the Appliances Load Profile database and save your profile from there.

Click on the Graphics button to display the time pattern of energy consumption based on the current entries and the consumption profile that has been defined.

Click on the **Holiday Periods** button to open the Holiday Periods dialogue.

2.3.15 Tariffs

This is where you set the tariffs for power supply to and from the grid (**Conditions/Tariffs** menu).

Clicking on the **To Grid Tariff** button opens the To Grid Tariff dialogue. From here you can define or load a tariff.

Clicking on the **From Grid Tariff** button opens the Load File dialogue and you can then choose from the tariffs provided in the database under From Grid Tariff. To help you choose the correct tariff level, a description of the tariff is given in the file reference field.

In the (Electricity) Tariffs dialogue, under **Supply Concept**, you need to select whether all PV energy produced should be fed into the grid (select **Full Supply**), or whether the energy requirement of the appliances connected to the system should first be covered (select **Own Use**).

Even if you select the full supply concept, you are still able to define the appliance load and thereby monitor the overall costs of electricity used by the appliances connected to the system.

2.3.16 Tariff Time Periods

The high tariff periods (HT) and any special tariff periods (ST) are defined here. These tariff periods are valid for the supply of energy both to and from the grid utility.

Winter Time: From… To:

Entry of the tariff period for winter is made in dd.mm format. .

Different Tariff Periods – Summer/Winter:

Select to enter separate tariff periods for summer and winter.

Define Special Tariff Periods:

Select to create a new worksheet for the entry of a special tariff period in addition to high and low tariff periods. Separate kilowatt-hour rates can be entered for these times in the Kilowatt-Hour Price dialogue. When a high tariff period is also defined as a special tariff period, this period is valid as a special tariff period.

New HT Periods Valid From:

With the assistance of these selection fields you can define which days in the week different tariff periods are valid on. The first column shows on which days of the week the times entered are valid.

High Tariff Periods:

You can enter up to 5 time periods (**from** ... **to** ... hours) per day. Enter these values in time format.

See also:

From Grid Tariff

2.3.17 Holiday Periods Dialogue

Up to three holiday periods can be entered. The entry should be made in date format (dd.mm).

If no holiday periods are to be defined, you will have to enter the same date in the fields labelled **From… To**.

In addition to the holiday periods, the **Energy Requirement** during the holidays is defined in this window as a percentage of workday consumption.

2.3.18 Load Profile

By clicking on the **New Load Profile** button you can define an additional load. You can define up to four separate electrical load profiles.

By clicking on the button with the symbol representing the electrical appliances (light bulb), the window for defining the load profile for the Electrical Appliances is activated.

The name given to the appliance load and the total annual electrical energy consumption entered is shown next to the electrical appliance symbol.

You will need for enter a From Grid Tariff for your electrical appliances. This is done in the Conditions/Tariffs menu.

The total annual electrical energy requirement for all of the appliances you have defined is shown in the bar at the base of the dialogue. The hourly maximum value is displayed after simulation.

2.3.19 Supplements

Supplements:

Here you can enter HT or LT energy and the load price, with any supplements, as a percentage figure.

Set Costs [€/a]: (eg accounting fees)

Set annual costs are entered here, such as measurement and billing costs, that must be paid regardless of the consumption.

See also:

From Grid Tariff

Discounts

2.4 System Menu

Here you will find all the commands you will need to define your PV system. In addition to technical data, you can define shade on the array/s.

Technical Data

Shade

2.5 Calculations Menu

If the system parameters have been defined and weather data has been selected, the programme is able to carry out a simulation of energy yields. After that an economic efficiency calculation is possible, once you have entered tariffs for energy supply to and from the grid.

The **Simulation** command cannot be accessed (the lettering is grey not black) when valid results are available (ie a simulation has already been carried out and the parameters remain unchanged). The **Economic Efficiency Calculation** command cannot be accessed when there are no valid simulation results available.

Simulation

Economic Efficiency Calculation...

2.6 Results Menu

With PV*SOL® you have a number of alternatives for evaluating the simulation results. The results are not saved, as the results files would be too large and you can simply and quickly re-run a simulation whenever you wish.

There is, however, a roundabout way of saving the results if required. This is done from within the Graphics facility in the **Table** menu command.

Most menu commands are only activated (ie the lettering is black not grey) after simulation. However, you are able to view the data loaded from the Weather Files, the parameters entered under Technical Data in the Detailed Project Report and the Variant Comparison at any time.

Annual Energy Balance

Energy and Weather Data...

To Grid Credit

From Grid Costs

Pollutant Emissions

Project Report

Variant Comparison

2.7 Database Menu

2.7.1 Database Menu

From the Database menu you can view the various database sections, make changes and add new files.

When entering the project data you will have to load the individual components for the PV system from the database files.

During the design and configuration of a project it is not possible to change the component values from the project screen, with the exception of the **To Grid Tariff** and the **Individual Appliances**. See also Project Design.

PV Module

Inverter – Grid Connected

Inverter – Stand-Alone

Battery

MPP Tracker

Load Profile

Individual Appliances

From Grid Tariff

To Grid Tariff

Pollutants

Loans

From here, on a number of worksheets, you can set the characteristics for the PV modules. Details on using the database are given under Project Design.

As in all database dialogues, there are the **Load**, **Save** and **Close** buttons and there is also a **Print** button.

Worksheet 1 – Basic Data:

Manufacturer and **Type** are allowed a maximum text length of 50 characters.

Output Tolerance [%]

The given module values are subject to fluctuations during manufacture. This is relevant mainly for the specification of current, voltage and power output.

Cell Type

The majority of cells consist of mono-crystalline or poly-crystalline silicon, with a few made of amorphous silicon.

New cell types will, however, soon be available.

Dimensions: Height [m], Width [m]

The height and width determine the module surface and therefore the PV array surface area. This surface area, based on the measurement of the modules, is referred to in the programme as the **Gross Module Surface Area**.

Worksheet 2 - U/I Characteristics under STC:

The specifications on this page are only valid for standard test conditions (STC). This means a module temperature of 25°C, a sunlight spectrum of AM 1.5 and 1000 W/m² irradiation.

MPP Voltage [V], MPP Current [A]

The power output of the modules is dependent on the module temperature and irradiation, and the module voltage. For each module temperature and irradiation value there is a current/voltage characteristic curve, and the working point on this curve determines the modules' power output.

The MPP is the working point on this curve (see also the U/I characteristic curve button on the sheet: U/I characteristics - part load) where the power output of the modules is the greatest (Maximum Power Point).

The MPP voltage and the MPP current are dependent on temperature and irradiation. This means that the voltage and current given here are only valid for standard test conditions. For all other irradiation and temperature values there is another MPP. This must be defined by the programme (see: U/I characteristics - part load).

Within the PV system this task is carried out by the inverter, which regulates the voltage of the PV generator to maximise current and voltage production (MPP tracking).

No-Load Voltage [V]

The voltage that arises when the module is load free. This value is also dependent on temperature and irradiation.

Short Circuit Current [A]

The electricity that flows through a short circuited module. This is also temperature and irradiation dependent.

Specified Power Output [W]

The power output that the module produces under standard test conditions according to the manufacturer's data sheets. The actual power output is defined from the module voltage and the module current, and is given in the **Calculated Power Output** field. In defining the installed PV power output, PV*SOL® always refers to the calculated power output.

Efficiency [%]

The module efficiency rate under standard test conditions. For the simulation, the programme determines the **Solar Module Surface Area** from the calculated power output and efficiency with the following formula:

$$\text{Nominal output(STC)} = 1000\ \text{W/m}^2 * \text{ETA(STC)} * \text{Solar module surface area}$$

Worksheet 3 - U/I Characteristics under Part Load Conditions:

Current and **Voltage** for a second working level are entered on this page. The values for a lower level of irradiation are important in order to be able to calculate the module efficiency curve. The efficiency specifications in data sheets are based on a module temperature of 25°C and irradiation of 1000 W/m², although for most of the year these levels are seldom reached. The efficiency rate at a lower level of irradiation is therefore very important for the simulation results. There are a number of important points to consider when determining the second working point (Module Efficiency - Part Load). Click on the **Help** button to view these. The programme will calculate the second working point for you if you click on the **Typical Part Load Efficiency** button.

You can view a graph of the characteristic curve calculated by the programme by clicking on the **Efficiency Curve**, **U-I Curve** or **U-P Curve** buttons.

Worksheet 4 – Other Characteristics:

Temperature Coefficients:

Voltage Coefficient [mV/K]

This value expresses how many degrees the voltage decreases when there is a rise in module temperature. The hotter the module, the lower the voltage, ie this coefficient is negative.

Current Coefficient [mA/k]

This value shows by how many amps the current increases when the module temperature rises. The higher the module temperature, the higher the current, ie this coefficient is positive.

Power Output Coefficient [%]

The hotter the module, the lower the power output. This coefficient is negative and is proportional to the nominal output.

Incident Angle Modifier [%]

The incident angle modifier is a characteristic of the material covering the module (glass). The glass reflects part of the radiation away from the module resulting in a loss of current. The incident angle modifier reduces the amount of direct radiation falling onto the module. The correction factor for diffuse radiation lost through reflection is assumed at 95%.

Maximum Module System Voltage[V]

Each electrical appliance has a maximum voltage limit. This value refers to the maximum voltage that a sub-array can support in order to ensure that no damage is caused to the modules. If the maximum voltage is too high, you should reduce the number of modules in series.

Specifications for the Dynamic Temperature Model:

Heat Capacity [J/(kg*K)], Absorption Coefficient [%], Emissions Coefficient [%], Weight [kg]

These are the parameters for the dynamic temperature model required for working out the thermal balance equation.

Click on **Load** to load one of the module files provided, to check on the values and correct if required.

Click on **Save** to save the values you have entered, either in the current file or as a new file. A message appears before a file is overwritten.

Close exits the dialogue without a message appearing.

If you want to print out the file that has been loaded last click on **Print**. This will be printed on the standard printer as specified in printer set-up.

2.7.2 PV Module

From here, on a number of worksheets, you can set the characteristics for the PV modules. Details on using the database are given under Project Design.

As in all database dialogues, there are the **Load**, **Save** and **Close** buttons and there is also a **Print** button.

Worksheet 1 – Basic Data:

Manufacturer and **Type** are allowed a maximum text length of 50 characters.

Output Tolerance [%]

The given module values are subject to fluctuations during manufacture. This is relevant mainly for the specification of current, voltage and power output.

Cell Type

The majority of cells consist of mono-crystalline or poly-crystalline silicon, with a few made of amorphous silicon.

New cell types will, however, soon be available.

Dimensions: Height [m], Width [m]

The height and width determine the module surface and therefore the PV array surface area. This surface area, based on the measurement of the modules, is referred to in the programme as the **Gross Module Surface Area**.

Worksheet 2 - U/I Characteristics under STC:

The specifications on this page are only valid for standard test conditions (STC). This means a module temperature of 25°C, a sunlight spectrum of AM 1.5 and 1000 W/m² irradiation.

MPP Voltage [V], MPP Current [A]

The power output of the modules is dependent on the module temperature and irradiation, and the module voltage. For each module temperature and irradiation value there is a current/voltage characteristic curve, and the working point on this curve determines the modules' power output.

The MPP is the working point on this curve (see also the U/I characteristic curve button on the sheet: U/I characteristics - part load) where the power output of the modules is the greatest (Maximum Power Point).

The MPP voltage and the MPP current are dependent on temperature and irradiation. This means that the voltage and current given here are only valid for standard test conditions. For all other irradiation and temperature values there is another MPP. This must be defined by the programme (see: U/I characteristics - part load).

Within the PV system this task is carried out by the inverter, which regulates the voltage of the PV generator to maximise current and voltage production (MPP tracking).

No-Load Voltage [V]

The voltage that arises when the module is load free. This value is also dependent on temperature and irradiation.

Short Circuit Current [A]

The electricity that flows through a short circuited module. This is also temperature and irradiation dependent.

Specified Power Output [W]

The power output that the module produces under standard test conditions according to the manufacturer's data sheets. The actual power output is defined from the module voltage and the module current, and is given in the **Calculated Power Output** field. In defining the installed PV power output, PV*SOL® always refers to the calculated power output.

Efficiency [%]

The module efficiency rate under standard test conditions. For the simulation, the programme determines the **Solar Module Surface Area** from the calculated power output and efficiency with the following formula:

$$\text{Nominal output(STC)} = 1000\ \text{W/m}^2 * \text{ETA(STC)} * \text{Solar module surface area}$$

Worksheet 3 - U/I Characteristics under Part Load Conditions:

Current and **Voltage** for a second working level are entered on this page. The values for a lower level of irradiation are important in order to be able to calculate the module efficiency curve. The efficiency specifications in data sheets are based on a module temperature of 25°C and irradiation of 1000 W/m², although for most of the year these levels are seldom reached. The efficiency rate at a lower level of irradiation is therefore very important for the simulation results. There are a number of important points to consider when determining the second working point (Module Efficiency - Part Load). Click on the **Help** button to view these. The programme will calculate the second working point for you if you click on the **Typical Part Load Efficiency** button.

You can view a graph of the characteristic curve calculated by the programme by clicking on the **Efficiency Curve**, **U-I Curve** or **U-P Curve** buttons.

Worksheet 4 – Other Characteristics:

Temperature Coefficients:

Voltage Coefficient [mV/K]

This value expresses how many degrees the voltage decreases when there is a rise in module temperature. The hotter the module, the lower the voltage, ie this coefficient is negative.

Current Coefficient [mA/k]

This value shows by how many amps the current increases when the module temperature rises. The higher the module temperature, the higher the current, ie this coefficient is positive.

Power Output Coefficient [%]

The hotter the module, the lower the power output. This coefficient is negative and is proportional to the nominal output.

Incident Angle Modifier [%]

The incident angle modifier is a characteristic of the material covering the module (glass). The glass reflects part of the radiation away from the module resulting in a loss of current. The incident angle modifier reduces the amount of direct radiation falling onto the module. The correction factor for diffuse radiation lost through reflection is assumed at 95%.

Maximum Module System Voltage[V]

Each electrical appliance has a maximum voltage limit. This value refers to the maximum voltage that a sub-array can support in order to ensure that no damage is caused to the modules. If the maximum voltage is too high, you should reduce the number of modules in series.

Specifications for the Dynamic Temperature Model:

Heat Capacity [J/(kg*K)], Absorption Coefficient [%], Emissions Coefficient [%], Weight [kg]

These are the parameters for the dynamic temperature model required for working out the thermal balance equation.

Click on **Load** to load one of the module files provided, to check on the values and correct if required.

Click on **Save** to save the values you have entered, either in the current file or as a new file. A message appears before a file is overwritten.

Close exits the dialogue without a message appearing.

If you want to print out the file that has been loaded last click on **Print**. This will be printed on the standard printer as specified in printer set-up.

2.7.3 Inverter – Grid Connected Systems

The characteristics for the inverter are entered in this window. Details on using the database are given under Project Design.

If you want to enter an inverter that can be switched to different voltage levels, you will have to enter the individual voltage fields as separate inverters with the characteristic data for each of these.

As in all database dialogues there are the **Load**, **Save** and **Close** buttons and there is also a **Print** button.

Manufacturer and **Type** are allowed a maximum text length of 50 characters.

DC Power Rating [kW]

DC stands for direct current and refers to the input side of the inverter. As this value is not clearly defined by inverter manufacturers, it is no longer used in PV*SOL and is shown for information only.

Max. DC Power [kW]

This value is also not clearly defined by inverter manufacturers. It is no longer used in PV*SOL and is shown for information only.

AC Power Rating [kW]

AC stands for alternating current and refers to the output side of the inverter. The AC power rating is the output that the inverter is designed for when in continuous operation. When the inverter is in continuous operation the power output is limited, with the AC power rating being the upper limit.

Max. AC Power [kW]

The output that the inverter can produce in 10 minutes. This value is not currently used in PV*SOL.

Stand-by Consumption [W]

If no energy is being delivered into the grid or to the electrical appliances, the energy required by the inverter itself still has to be accounted for. In addition to the stand-by consumption there is also night consumption.

Night Consumption [W]

The inverter switches itself off during the night, but still uses a small amount of energy.

Input Level [W]

The minimum amount of energy to be produced by the PV generator before the inverter can function.

Nominal DC Voltage[V] / Nominal DC Current [A]

The input voltage or the input current of the inverter, when delivering nominal power output.

Number of MPP Trackers

The number of independently operating MPP regulators.

For multi-string appliances, this value is greater than 1.

Max. Input Current per MPP Tracker [A]

This current limit per MPP tracker should not be exceeded. (Only active if the number of MPP trackers is greater than 1.)

Max. Recommended PV Output per MPP Tracker[kW]

See **Max. Recommended PV Output [kW]**

Maximum Input Voltage [V] / Maximum Input Current [A]

This level of voltage or current should not be exceeded, otherwise the inverter will be damaged.

Upper and Lower Voltage Levels for the MPP Range [V]

Within this voltage range, the inverter is able to control the MPP tracking. The inverter finds the optimal voltage for the PV generator within this range, so that the generator's power output is maximized.

MPP Adjustment Efficiency [%]

The adjustment efficiency provides a measurement of how close the inverter's working point is to the PV generator's maximum power point (MPP). The programme differentiates between the power ranges <20% and >20% of the nominal output. The adjustment efficiencies are taken into account during simulation in defining the inverter's performance ratio.

Characteristic Curve - Inverter

This button opens the Characteristic Curve – Inverter dialogue, so that the you can enter the conversion efficiency depending on the input power. These values should be obtained from the inverter manufacturer.

The European efficiency is calculated with the following formula:

$$Wg(EU) = 0.03*Wg(5\%) + 0.06*Wg(10\%) + 0.13*Wg(20\%) + 0.1*Wg(30\%)+ 0.48*Wg(50\%) + 0.2*Wg(100\%)$$

Deviation of the Input Voltage from the Nominal Voltage

The inverter's efficiency characteristic curve is entered for the nominal voltage. If the inverter is not operated at its nominal voltage, there is a change in the efficiency of the inverter. Whether the efficiency increases or decreases is dependent on whether the inverter has a transformer, or not. The following can be used as a rule of thumb:

- The efficiency of an inverter **with a transformer reduces** with rising input voltage by about 1% per 100 V.
- The efficiency of an inverter **without a transformer increases** with rising input voltage by about 1% per 100V.

Click on **Load** to load one of the inverter files provided, to check on the values and correct if required.

Click on **Save** to save the values you have entered, either in the current file or as a new file. A message appears before a file is overwritten.

Close exits the dialogue without a message appearing.

If you want to print out the file that has been loaded last click on **Print**. This will be printed on the standard printer as specified in printer set-up.

See also:

Inverter

Inverter – Stand-Alone Systems

2.7.4 Inverter – Stand-Alone Systems

The characteristics for a stand-alone system inverter are entered in this window. Details on using the database are given under Project Design.

Manufacturer and **Type** are allowed a maximum text length of 50 characters.

Nominal DC Output:

The direct current flows into the inverter. The nominal output is the power rating at which the inverter, under continuous operation, is designed to run.

Nominal AC Output:

This refers to the current that flows out of the inverter. The nominal AC output is the power rating that is available for the electrical appliances connected to the system.

Stand-by Consumption [W]:

If no energy is being delivered into the grid or to the electrical appliances, the energy required by the inverter itself still has to be accounted for.

Nominal DC Voltage:

The nominal DC voltage must match the battery's nominal voltage.

Nominal AC voltage:

The voltage corresponds to the nominal voltage of the appliances.

Characteristic Curve - Inverter:

This button opens the Characteristic Curve – Inverter dialogue, so that the you can enter the conversion efficiency depending on the input power. These values should be obtained from the inverter manufacturer.

See also:

Inverter

Inverter – Grid Connected Systems

2.7.5 Inverter Characteristic Curve Dialogue

The conversion efficiency is the relationship of the power output to the power input, dependent on the inverter power at that time.

The specification of the efficiency given in manufacturers' data sheets relates to the nominal output (power rating), which PV systems, however, are not able to deliver at most times of the year. Therefore the part load operation is much more important for the simulation results.

The programme requires **7 support points** to define the characteristic curve, ie the efficiency at 0, 5, 10, 20, 30, 50 and 100% of the nominal output.

To view the characteristic curve in graphic form, click on the **Graph** button.

For grid connected systems, the European efficiency support points are fixed and displayed. If changes are made, these are first calculated on exiting the entry field.

See also:

Database: Inverter

2.7.6 Battery (not available with PV*SOL®-N for grid connected systems only)

The following battery characteristics are entered in this dialogue:

Manufacturer and **Type**:

You are allowed to enter a maximum of 50 characters.

Voltage:

The battery's nominal voltage.

C20 Capacity: Battery capacity with a discharge time of 20 hours.

Capacity:

The product of voltage and C20 capacity. This is calculated within the programme by clicking on **Calculator**.

Self-Discharge:

The details from the battery's product data sheet should be recalculated to % per day.

Average Charge and Discharge Efficiency:

If you do not have these specifications to hand, please use the programme's default values.

Click on **Load** to load one of the battery files provided, to check on the values and correct if required.

Click on **Save** or **Save as…** to save the values you have entered, either in the current file or as a new file. A message appears before a file is overwritten.

Close exits the dialogue without any message appearing.

If you want to print out the values from the file that has been loaded last click on **Print**. The information will be printed on the standard printer as specified in printer set-up.

2.7.7 MPP Tracker (not available with PV*SOL®-N for grid connected systems only)

MPP trackers are not standard system elements, but are produced especially for the various stand-alone systems. They are also partly integrated into other system parts (charge controller).

For the MPP tracker the following data is required:

Reference:

The text entered is shown as the file reference in the load file dialogue.

Nominal Output:

The nominal output corresponds to the power output of the PV generator.

Upper and Lower Voltage Levels for the MPP Range [V]:

The MPP tracker functions within this voltage range. The MPP tracker finds the optimal voltage for the PV array within this range, so that the array's power output is maximized.

MPP Adjustment Efficiency [%]:

The adjustment efficiency provides a measurement of how close the MPP tracker's working point is to the PV array's maximum power point (MPP).

Characteristic Curve – MPP Tracker:

This button opens the "Characteristic Curve – MPP Tracker" dialogue, so that the you can enter the conversion efficiency depending on the input power. The programme requires seven values to be entered for the characteristic curve: the efficiency at 0, 5, 10, 20, 30, 50 and 100% of the nominal power.

Click on **Graph** to view the characteristic curve.

Click on **Load** to load one of the MPP tracker files provided, to check on the values and correct if required.

Click on **Save** or **Save as…** to save the values you have entered, either in the current file or as a new file. A message appears before a file is overwritten.

Close exits the dialogue without any message appearing.

2.7.8 Load Profile

The electrical load profile dialogue appears, which shows an hourly breakdown of consumption and the annual consumption in both chart and table format. For more information on how to use the database see: Project Design.

With the **Load** and **Save** buttons you can open the Load and Save File dialogue and you are able to load a file from the database or save a file to the database.

By clicking on the tabs above the chart you can view the various loads for the type of day selected, both in chart and table format.

If you want to **Edit** the profile values, you can do this in the table:

- Click on the value to be changed within the table.
- The hour and its corresponding value are highlighted.
- The value appears in the field at the head of the table.
- Key in the new value.
- Click on any other value in the table.
- The new value is loaded and appears in the chart.

If the values split over 24 hours do not add up to 100%, the programme will do this if you click on the **100%** button.

With the **Copy** and **Add** buttons you are able to copy a consumption profile for one typical day to another:

- Load the profile that you want to copy by clicking on the tab above the chart.
- Click on **Copy**.
- Change to the profile that you want to overwrite with the profile you have copied (click on the tab above the chart).
- Click on **Add**.

2.7.9 Individual Appliances

The energy requirement for the individual appliances is defined in this dialogue.

The individual appliances are an exception among the database files, in that you are able not only to select the appliances from the ”Individual Appliances” dialogue, you are also able to define them from within this dialogue. However, you are still able to create and amend individual appliance profiles from within the database.

The following data is required:

Name: The text entered appears as a file reference in the ”Load File” dialogue.

Type: Click on the **arrow button** to view a list of the types of appliances available. The subdivision assists in the optimum setting of operating times, which is why the dialogue distinguishes between the various types.

User-Independent Appliance

User-Dependent Appliance

Short-Time Use Appliance

Light

Output: the entry should include all appliances.

Monthly Operation Bar: click on a field above a **month** to switch off operation for the whole of that month (the field turns from green to white). Click on the **magnifying glass** to switch off operation for individual days. (Green field = in operation, white field = not in operation.)

By clicking on **Load** you are able to load an appliance from the database, in order to change the data provided.

If you click on **Save** you are able to save the values entered into the existing file or as a new file.

Click on the **Graphics** button to view the calculated energy requirement for the appliance in various formats: graph, chart, table. You are able to save and print these, and also copy into other documents/programmes.

2.7.10 From Grid Tariff

The tariff for electricity from the utility grid used by the electrical appliances is defined here. For more information on how to use the database see: Project Design.

From the Load and Save File dialogue and you are able to load a tariff file from the database or save a tariff file to the database [*.tar].

The tariff reference is given in the field labelled **Name**.

High Tariff and Special Tariff Periods are defined in the Tariff Time Periods dialogue. These times are valid for electricity drawn from the grid as well as for energy exported to the grid.

The kilowatt-hour prices for each tariff time period (ie HT – high tariff, LT – low tariff and ST – special tariff) are entered in the Kilowatt-Hour Price dialogue.

Click on the Power Measurement button to define the type of power measurement (¼ hour power measurement, 96 hour measurement) In addition, the prices for the energy provided by the grid utility is defined here and the light or heavy load periods are entered.

The grid utility discounts and supplements can be entered separately in the Discounts and Supplements dialogue.

2.7.11 To Grid Tariff

Unlike the other database files, the **To Grid Tariff** can be selected and defined in both the **Conditions/Tariffs** menu dialogue and in the Economic Efficiency Calculation... dialogue. However, you can also define the To Grid Tariff via the **Databases** menu in the main menu bar.

A reference describing the data record can be entered in the upper text field.

Period of Validity for Tariff

For the first years, the **To Grid Tariff** is usually set at a higher rate. Thus you can take account of any subsidised electricity provided for a set period, following which the legally set minimum rate is paid.

To Grid Tariff after … Years

Here you are able to define a different To Grid Tariff which is received following the initial period.

Number of Power Levels

Here you can set the number of **Power Levels** required to define the different **To Grid Tariffs**.

Tariff Zones/Graduated Tariff Rates

The method used for calculating the resulting **Payment Received for Grid Supply** varies according to the selection of either **Tariff Zones** or **Graduated Tariff Rates**. If Tariff Zones is selected, the result is an almost constant change in the payment, whereas the selection of Graduated Tariff Rates produces a jump from one payment rate to the next when the defined Power Level is reached.

Tariff Zones:

A mean **To Grid Tariff** for all **Power Levels** up to the **Installed PV Power** is calculated. For example:

0-30 kW - €1

From 30 kW - €0,50

A system size of 50 kW therefore produces a Payment Received for Grid Supply of 30/50*€1 + 20/50*€0,50 = €0,80.per kWh.

Graduated Tariff Rates:

In this case the To Grid Tariff is calculated direct from the Installed Power. Using the above example, this would result in a Payment Received for Grid Supply of €0.50 per kWh on all electricity supplied.

Payment Received for Grid Supply – High Tariff/Low Tariff different

If this option is selected, an additional field appears in which you can enter the **To Grid Tariff** at two different rates: a **High Tariff** and a **Low Tariff**.

The timings for High and Low Tariffs are the same as those for the **From Grid Tariff**. The timings are therefore dependent on the From Grid Tariff.

2.7.12 Pollutants

You can define a new pollutants file here, which can then be loaded into a project from the **Conditions/Pollutant Mix** menu.

In the **Text** field a file reference describing the data record is given, that was entered when saving the file.

Different values are required for simulating grid connected and stand-alone systems.

Grid Connected Systems

In the first column you need to enter the specific pollutant emissions that **occur** on production of the electricity required to supply energy from the grid.

In the second column you need to enter the specific pollutant emissions that are **avoided** by feeding PV energy into the grid.

This kind of differentiation is necessary when it can be expected that the grid utility will use different power plants for producing high and low peak electricity. For example the energy fed into the grid could suppress basic load electricity production with energy drawn from the grid occurring during peak times.

Stand-Alone Systems

For stand-alone systems the pollutant emissions for the **Back-up Generator** are given.

Click on **Load** to load a new pollutant evaluation file from the database or on **Save** to save new specifications to the database.

All emissions files must have the file ending *.emm. The directory that appears on opening the dialogue can be set under **Options/Drives**.

The database that comes with the programme consists of values from the Integrated Systems Total Emissions Model (GEMIS), published in 1990 by the German state of Hesse's Ministry for the Environment, Energy and Federal Matters.

2.7.13 Loans

From here you can enter the parameters for any loans taken out to finance the PV system.

Details on using the database are given under Project Design.

As in all database dialogues, there are the **Load**, **Save** and **Close** buttons and there is also a **Print** button.

The entry parameters for a loan are:

Reference

The reference, with a maximum text length of 50 characters, is required for selection in the **Financing** dialog of the Economic Efficiency Calculation.

Loan Capital

The amount of the loan is entered as a percentage of the investment volume.

Term

The time period that has been arranged for paying back the loan.

Loan Interest

The amount of interest that has to be paid on a loan.

Repayment-Free Initial Period

The years in which no loan repayment is required. A maximum period of two years is allowed.

2.8 Options Menu

2.8.1 Options Menu

The Options menu is used to enter specifications that are independent from the programme and to define the basic settings for the use of the programme.

See:

Drives...

Einstellungen

2.8.2 Paths...

You are able to define the directories for all file types by clicking on the corresponding button. A directory dialogue opens in which you can define a new directory path.

These settings are required in the programme for standard drive selection in the Load and Save File dialogue.

The individual components are searched for and saved in the following standard sub-directories:

	File Extension	Directory
Projects	.prj	...\Projects\
PV-Modules	.mod	...\Database\Modules\
Inverter (Grid Connected)	.wrn	...\Database\Inverters Grid Connected\
Inverter (Stand-Alone)	.wra	...\Database\Inverters Stand Alone\
Weather Data	.wbv	...\Database\Meteo\
Batteries	.acc	...\Database\Accumulators\
To Grid Tariff	.eta	...\Database\Tariffs\
From Grid Tariff	.tar	...\Database\Tariffs\
Loads	.slg	...\Database\Profiles\
Individual Appliances	.vbi	...\Database\Consumption\
Pollutants	.emm	...\Database\Additional\
MPP Tracker	.mpp	...\Database\Additional\
Shade	.sch	...\Database\Additional\
Loans	.cre	...\Database\Additional\

2.8.3 Settings

2.8.3.1 Settings

System Check

Here you can enter the settings that are required for the **System Check**.

Temperature and irradiation maximums are usually calculated from the Weather File.

However, if you are certain about the maximum values that you wish to use as the basis for system calculation, you can enter these as the set values.

Projects

On the second dialogue worksheet, **Projects**, you can specify with which project the programme should open. You can select that either a new project or the last project worked on appears each time the programme is started.

“No monitoring of project components” gives you the option of selecting that various Messages appear (click on field) or do not appear (leave field blank) during programme use:

see Project Design.

Graphics

- Define Company Logo for Project Report Heading

  Here you can select a logo to appear in the header of the project report. If you select “Show Company Logo on Screen”, the logo appears on PV*SOL’s main screen as a background image.

- Select Background Image

  Here you can make your own selection of a background image for stand-alone and grid connected systems in PV*SOL.

Calculation Model

Here you are able to select whether the Dynamic or the Linear Temperature Model is to be used. You can also select to allow for the dependency of the inverter’s efficiency on the input voltage. This only makes sense, however, if you want to compare a new project with the results of an old project from a previous version of PV*SOL (up to and including V2.3).

Please note that these setting remain in force after you exit the project.

2.8.3.2 Temperature Model

Under Options/Settings you can select which Temperature Model you would like to be used in the calculations.

The temperature of the PV module is important for calculating the power output. Temperature increase of 10°C leads to a power loss of about 5%.

With the **Simple Temperature Model** the module temperature is determined in linear dependence on the irradiation:

T module = T external + U * (G / Gstc),

and k is dependent on the type of module mount.

With the **Dynamic Temperature Model**, the thermal balance equation is solved. The 1 hour simulation step is, if required, subdivided into minute-long time steps.

To solve the thermal balance equation, the following module data (see database: PV Module) is required: module mass, heat capacity, absorption coefficient and emissions coefficient. In addition, the scalar wind speed from the Weather Files, as well as the height of the system, (see dialogue: Technical Data/Calculation Model/Losses) are included in the calculation.

As the subdivision of the calculation steps leads to a considerably longer simulation time, and, for rough calculations, the simple temperature model is perfectly adequate, the user is given the option to carry out the calculation with whichever temperature model is preferred.

2.8.3.3 System Check

In order to check the interconnection of modules and inverters or MPP trackers and batteries, and the influence of losses in the direct current cabling, click on the **System Check** button before exiting the Technical Data dialogue. Depending on the system connections the system check takes place on one or a number of pages.

If new Settings for temperature and irradiation maximums have been entered under Options/Settings, you will be reminded of this by a message at the base of the window.

No Discrepancies

You should only exit the ”Technical Data” dialogue when, after the system check, the following message appears:

On checking the system no discrepancies have been found!

Further Calculation Possible

If discrepancies appear, but a simulation of the system is still possible, the following message appears:

Please check the system parameters! Further calculation possible.

Incorrect Database Data

The system check requires that module and inverter data is saved in the database. If specifications are missing, or if the specifications are not physically possible, a message appears:

The database files contain incorrect values!

Select Components

If you go to the system check before loading the module and inverter specifications, this message appears:

Please select components from the database files available!

Check System Parameters

If during the system check errors are found that have to be corrected before simulation can take place, the message is:

Simulation is not possible until you have checked and corrected the system parameters!

The following checks occur for grid connected systems:

Output checks

The inverter’s nominal output and maximum PV output are compared with the installed PV output per inverter. The inverter’s capacity is defined from the PV output divided by the inverter’s nominal output. A message appears if the capacity is less than 90% or more than 110%. Capacities less than 20% and more than 300% are not accepted.

If the PV output is larger than the inverter’s nominal output, the inverter must reduce the output to the inverter’s nominal output. If the PV output is significantly less than the inverter’s nominal output, the inverter works at a low efficiency rate.

MPP Voltage Check

The inverter’s MPP tracking field is compared with the MPP voltages of the modules connected in series. The voltage decreases with rising temperature and decreasing radiation.

Boundary values in defining the MPP voltages that occur in the PV system are:

- a working point for high irradiation and low temperature to define the maximum MPP voltage, and
- a working point for low irradiation (onto the tilted module surface) and maximum module temperature to calculate the minimum MPP voltage.

The working points are dependent on the:

- location of the system,
- orientation and inclination of the modules, and the
- type of module mount.

PV*SOL® takes the lowest module temperature as being equal to the lowest external temperature in the weather data record being used. Maximum radiation is taken from the weather data record for the month in which this temperature occurs, for the preceding month, and for the following month, and is converted onto the tilted module surface. For example, with an orientation due south and a 30 inclination, the values for two different locations are:

- Berlin: 14 C und 858 W/m²
- Freiburg: 11 C und 957 W/m²

To define the system's lowest MPP voltage, the value of the irradiation during module part load performance is taken from the module database as the minimum irradiation. For example: 300 W/m².

The maximum module temperature for this irradiation is defined by the maximum temperature at the system location plus an offset. The maximum system location temperature is read from the weather data record being used. The offset is dependent on the module mount and the irradiation.

It applies that:

$T_{max,Modules} = T_{max,Sys.\ Location}$ + factor * G_{min} / 1000.

Factor = 20 for free-standing modules,

Factor = 30 for rooftop mounting with ventilation space, and

Factor = 45 for roof or façade-integrated modules without ventilation space

This gives, for example, an offset of +9°C on the external temperature for modules with ventilation space, and a minimum irradiation of 300 W/m².

If under Options/Settings/System Check you select **Set Values,** you can enter temperature and irradiation extremes, which are then used in the system check.

The module array's MPP voltage is calculated for both of the working points described above, and then compared with the inverter's MPP tracking range.

A message warning of discrepancies appears if the inverter's threshold values vary by more or less than 10% from the modules. A value over 50% less than the lower MPP threshold is not permitted.

Overstepping the upper MPP threshold is restricted at the next stage by the strict observation of the maximum no-load voltage.

Upper Voltage Threshold Check

The inverter's maximum system voltage must not be exceeded on any account. Exceeding the inverter's upper voltage threshold can cause irreparable damage to the inverter.

The maximum occurring voltages should be checked very carefully.

As a comparative value PV*SOL® defines the module array's no-load voltage at the working point: minimum module temperature and maximum irradiation. This point has already been calculated for the MPP voltage check (see: MPP Voltage Check).

A message that the critical voltage has been reached appears if the module array's no-load voltage equals the maximum inverter voltage.

You are able to continue with simulation, but you should take into account when planning your system, that exceeding the maximum inverter voltage can cause irreparable damage to the inverter.

Exceeding the maximum voltage by 25% is not permitted.

The following checks are made on stand-alone systems:

Stand-Alone System Inverter AC Output Check

For AC appliances the inverter's nominal AC output and the appliances' maximum output are compared to ensure that the inverter can deliver the maximum output for the appliances.

Without a back-up generator, a message appears if the inverter output is less than 98% or greater than 120% of the appliances' maximum output. Outputs less than 33% and greater than 500% of the appliances' maximum output are not accepted.

If a back-up generator is used, this is able to cover the consumption directly, ie the back-up generator's energy does not flow through the stand-alone system inverter. The upper threshold remains the same, but the programme does not strictly set the lower threshold.

Stand-Alone System Inverter Voltage Check

For the AC appliances, the battery voltage is compared with the inverter voltage. Both components are loaded from the database and have to be checked against the system voltage.

Battery Voltage Check

If your system has direct battery connection, the battery voltage sets the modules' working point. The battery voltage is dependent on the charge condition. PV*SOL® works with a characteristic curve for the (averaged) voltage.

These benchmark figures are compared with two working points for the modules' MPP voltage, ie the MPP voltage at 500 W/m² and 25°C, and at 1000 W/m² and 25 C (STC)

A message appears if the minimum battery voltage is less than 60% and the maximum battery voltage is larger than the corresponding MPP voltage.

Simulation is blocked if the minimum battery voltage is less than 40% and the maximum greater than 110% of the corresponding MPP voltage.

MPP Tracker Output Check

If an MPP tracker is used, a check is required to see if the MPP tracker's output corresponds to the PV output. If the figure is exceeded the PV energy produced will be reduced, if the figure is not reached the MPP tracker works at a poor efficiency rate.

A message appears if the MPP tracker's output is less than 90% and more than 120% of the PV output. MPP tracker outputs less than 33% and more than 500% of the PV output are not accepted.

MPP Voltage Check

The MPP tracker's MPP tracking range is compared with the module array's MPP voltages. The voltage decreases with increasing temperature and decreasing radiation. The definition of the working points is as described in the grid connected system check.

For both of these working points the module array's MPP voltage is calculated and compared with the MPP tracker's MPP tracking range.

A message warning of discrepancies appears if the MPP tracker's threshold values vary by more or less than 10% from the modules. Not reaching the lower MPP threshold of around 50% or exceeding the upper MPP threshold of around 25% is not permitted.

Cabling checks are made on both types of systems, and on each sub-array.

DC Cabling Check

The flow of current through the cabling under standard test conditions (STC) is defined by the module current flow under STC and the number of parallel-connected modules in an array. This should not be more than the permitted electrical capacity of the cabling.

In the programme, the maximum capacity for group 3 insulated copper wiring is based on the Federation of German Electricians' regulations. Relative cabling losses are calculated from the cabling resistance, electricity and voltage under standard test conditions.

Cabling losses of above 20% are not accepted and PV*SOL® produces a message when these are above 5%.

2.8.3.4 Database Monitoring System

When a mismatch is uncovered by the database monitoring system, a corresponding message appears on screen. For example:

1 In PV Array 1 no module file has been selected from the database! Do you want to select a PV module?
If so click on the PV Module button.

2 The database file for the module
data in PV Array 1 no longer exists!
Do you want to save the data to a new file?

3 The database file
c:\pvsol\biblio\module\mei76.mod
has been changed!
Load file data into your project?

Checks 1 and 2 take place when the corresponding dialogue (Tariffs, Technical Data, Appliances) is closed with ”OK”. These messages are for information and can be closed by clicking on ”No”.

Check 3 takes place before simulation and, for modules and inverters, additionally when the ”Technical Data” dialogue is opened.

It is best to answer ”Yes” to the question ”Load file data into your project?” (except in the instance when you open an old project and want to simulate the old conditions), or to select ”Accept All” beforehand. (see Message: ... Database File...).

2.8.3.5 Message: ... Database file ...

The database file has been changed! Load file data into your project?

Components from the corresponding Database are loaded from the dialogues: Tariffs, Polutant mix, Technical Data and the load pattern in the Electrical Appliances dialogue. The programme loads the corresponding values and notes the file name.

If you change the database files that have been loaded or saved in a project, the programme informs you before simulation, that you have made changes to the database file without loading the new values into the project.

If you answer YES the project data is updated with the corresponding amended database data; if you answer NO the original values are retained.

Because all the database files that are loaded into a project are checked before simulation, you can click on **Accept All** so that you only have to answer the question once.

Cancel ends not only the data checks, but also the simulation.

This message appears for modules and inverters, and also on opening the technical data dialogue.

No data checks for "To Grid Tariffs"!

2.9 Conditions Menu

2.9.1 Conditions Menu

Before a simulation can be carried out, the ecological and economic conditions have to be entered or confirmed using the menu commands listed to below.

These details belong to the system, but are dependent on the location.

With the exception of the To Grid Tariff this information is given by loading files from the database (either those delivered with the programme, or any you have defined yourself in the Database).

Weather Files

Pollutant Mix

Tariffs

2.9.2 Weather Files

With the **Conditions/Load Weather File** menu command you open the Load and Save dialogue, from which you can load the weather file for the project location or the site closest to the project location. The files (eg London.wbv) contain values over a one year period for global radiation, external temperature and scaled wind speed in hourly format.

The current project weather file location appears on the main screen in the area containing the project details (underneath the menu bar). When you start a new project design the weather file used in the previous project is automatically loaded into the new project.

The weather data have been calculated from monthly mean values over a ten year period, enabling a weather generator to produce a characteristic hourly sequence.

It is possible to load weather files from the German Weather Service in the form of test reference years (file ending **.try).** The data required by PV*SOL will be automatically selected.

It is also possible to convert weather data from METEONORM Weather Data Records.

Weather data can be viewed in graph format before and after simulation with the menu command **Results/Energy and Weather Data...**. Wind data is only evaluated when the “Dynamic Temperature Model” is selected under **Options/Settings/Calculation Model**.

The irradiation onto the (tilted) PV surface, combining diffuse and direct radiation, is generated from global radiation.

The ground reflection (albedo), entered in the **Technical Data/Calculation Model/Losses** dialogue, is accounted for as a diffuse radiation gain.

The radiation reflected off the module surface is accounted for as a reflection loss. After simulation you can view this data in diagram format under **Results/Energy and Weather Data...**. The details are divided into radiation onto the tilted PV array surface and radiation minus reflection and are shown in W/m².

Reflection losses on the module surface lead to a decrease in the module’s efficiency.

2.9.3 Pollutant Mix

Pollutant Emissions results are loaded from the (Conditions/Pollutant Emissions/)Load file dialogue. Here you can choose from a selection of files provided under Pollutant Mix in the database.

If you want to define a new pollutant mix, you can do this via the **Database/Pollutant Mix** menu. Once saved you can then use the file for future projects.

2.10 Help Menu

You can also access this menu command by use of the F1 key from anywhere within the programme.

Via the **Internet Service** you are able to download a PV*SOL® **Order Form** from the internet, or find out more about Valentin Energy Software.

The menu command **Info** provides details on the programme such as the PV*SOL® version number.

Changing the PV*SOL® version you are using is possible with the **Change Registration** command.

For example, this is necessary if you want to convert the Time-Limited Version to the Full Version, or the Grid Connected Only Version to the Version for both Grid Connected and Stand-Alone Systems.

From the Change Registration command, when prompted, place the new licence disk in the drive. This will release the new version for immediate use.

3 Graphics

3.1 Graphics

With the assistance of the **Graphics** function you are able to print out or display on screen all of the values given in the programme. You can choose from a selection of formats.

Annual variations in weather data (radiation, temperature, wind), PV array power output, energy supply to and from the grid, energy requirement for electrical appliances, and evaluation values such as energy supply and performance ratios can be displayed, for any period in the year and simulated, in hourly, daily or monthly format.

Up to eight results data records can be displayed in graphic form. You can also open a number of graphics windows and sort them on the screen as you wish.

The presentation format can also be changed as required.

All axes and axes' labels can be formatted and repositioned. The output values can be presented as a line graph or a bar chart. The selection of colours used can be changed. The scale of the axes and the position of the axes' coordinates can be adjusted. The legend text can be dragged and dropped over the whole document area and the title can be edited with a double click.

The results can also be displayed in table format and saved as an ASCII file if you want to use an external programme to evaluate the data.

Graphics Screen

Formatting of Graphs

Formatting the Y-Axis

Formatting the X-Axis

Printing Graphics

Graphics in Table Format

Speed Buttons on the Graphics Screen

3.2 Graphics Screen

Legend

This field contains a description for each data record being displayed.

If energies are illustrated, the sum of the energy in the selected period is shown next to the name of the data record.

For power output, temperatures, wind speed and evaluation quantities (energy coverage, performance ratios and efficiencies) mean values for the period are shown.

The legend can be selected and repositioned.

Title

By double clicking on the title frame a dialogue window opens in which you can give the graph or chart a new title. When you close this window the new title appears in the title frame. The title can dragged and dropped with the mouse to any position within the graphics window.

Co-ordinates Field

At the base of the graphics window a field displays the actual co-ordinates indicated by the mouse pointer when it is located within the diagram. The date and time, as well as the x-value for the position of the mouse pointer are shown.

Selecting and Amending the Data and Axes

The individual data records displayed in the graph or chart and the x and y-axes can be selected by a single click of the left mouse button. The selection is shown by points along the lines in a line graph and on the bars in a bar chart. Click just below the lines for a line graph and the x axis, just under the top of one of the bars for a bar chart and to the left of the line for the y-axis.

By double clicking on the x or y-axes the dialogue window Formatting the X-Axis or Formatting the Y-Axis appears. By clicking with the right mouse button on either the axes or the graph a pop-up menu appears with the corresponding menu commands.

You can quickly change the format of the selected data record or axes by using the Speed Buttons.

3.3 Formatting of Graphs

The menu labelled **Graphs** lists the (selected) data records that can be displayed in graph, chart or table form.

For each data record the menu command **Own Y-Axis** enters an additional y-axis into the diagram assigned to the data record selected.

Under **Graphs** you can select a data record and at the next menu level select a variety of formatting options. Here you can select *line graph* or *bar chart* format and *bold* or *normal* line display.

With *change colour* you can select from a wide range of colours for the lines or bars in your graph or chart.

By choosing the command *invisible* the selection is suppressed but not deleted.

3.4 Formatting the X-Axis

In this dialogue window you can define the time period to be displayed in a graph or chart as well the time period over which the data record values are to be summarised or averaged out.

Column Width

The column width represents the time period within which the data is presented. Depending on which unit you have selected, the data record values are either summarised (energy) or averaged out (power output, temperatures) for the interval selected.

Display From

The date from which the data displayed in the graph should begin is entered here (in date format).

Display Interval

Here you should enter the period over which the data should be displayed in the graphic.

Units

The choice of units for the bar width and display interval (hours, days, weeks, years) is made from the pull down menus. You will need to enter the multiples of these units in the fields provided.

3.5 Formatting the Y-Axis

The y-axis is formatted in this dialogue window.

Unit

Select the unit to be displayed from the field labelled Unit. If you select **Position on Right** the y axis will be placed on the right-hand side of the diagram.

Position of the Y-Axis

In this field you can select the cross-over point of the axes. You can select either minimum (zero) or maximum, or you can enter a value yourself.

By selecting the field **Own Scale** you can format another y-axis for the selected data record.

Minimum Value

Enter the smallest value to be illustrated for the data record.

Maximum Value

Enter the largest value to be illustrated for the data record.

Main Intervals

The labelled intervals along the y-axis.

Sub-Intervals

The division of the main intervals along the y axis.

3.6 Printing Graphics

The usual WINDOWS print dialogue appears in which you can select the settings and printer desired.

3.7 Graphics in Table Format

The graphs selected in the Energy and Weather Data... dialogue window can be displayed in table format. Just click on the **Table** menu to switch to table format.

The various recording stages and intervals are incorporated from the graph into the table. If you want to change these go to the menu **Axes/X-Axis**, and make the changes in the dialogue window. You can also quickly change the display interval units from the **Display** menu.

Clicking on the menu **Line/Bar** switches back to line graph/bar chart format.

The position of the decimal point depends on the y-axis' main interval setting. To **Edit** the main interval setting you have to first go back via the **Line/Bar** menu and then to **Axes/Y-Axis**. You can then make amendments to the main interval or the units and then go back to **Table**.

From the **File/Save As** menu you can save the results as an ASCII file and from **File/Copy** you can copy the values for pasting into other spreadsheet programmes such as EXCEL (or use the speed button).

3.8 Graphics Screen Speed Buttons

By using the speed buttons you can perform a variety of functions and quickly change the format of the selected parts of the graph or chart or axis.

Print Graphic.

Copy Graphic (eg to paste into EXCEL for further processing).

Go to next or previous time period.

Go to first or last time period.

Enlarge or reduce font size of selected area of graphic.

Change between normal and bold font in selected area of graphic.

Change font.

Change selected data record to line graph or bar chart.

Add grid lines.

4 Results Menu

4.1 Results Menu

With PV*SOL® you have a number of alternatives for evaluating the simulation results. The results are not saved, as the results files would be too large and you can simply and quickly re-run a simulation whenever you wish.

There is, however, a roundabout way of saving the results if required. This is done from within the Graphics facility in the **Table** menu command.

Most menu commands are only activated (ie the lettering is black not grey) after simulation. However, you are able to view the data loaded from the Weather Files, the parameters entered under Technical Data in the Detailed Project Report and the Variant Comparison at any time.

Annual Energy Balance

Energy and Weather Data...

To Grid Credit

From Grid Costs

Pollutant Emissions

Project Report

Variant Comparison

4.2 Annual Energy Balance

The quickest way to view the most important results after simulation is to go to the **Annual Energy Balance**.

The annual results for energies and various evaluation dimensions are given in table format.

The output values vary according to the type of system.

If you have defined a PV system with a number of sub-arrays the values for each array are each given on a separate sheet.

You will find more details on output values under the heading Definitions

If you want to print the results go to **Project Report/Summary**.

If you want to view the values over a period of time go to Energy and Weather Data.

4.3 Energy and Weather Data...

A window for Graphics selection appears when you go to this menu command.

The majority of values and simulation results can first be seen after Simulation. Only the weather data from the weather file can be viewed before simulation, ie horizontal radiation, wind speed (scalar) and external temperature.

If you have defined a PV system with a number of sub-arrays, a curve for each array can be viewed on a separate sheets.

You can select up to 8 curves from the various pages.

Click on **OK** to exit the dialogue and the graph appears. The curves can be viewed and printed in various forms. It is also possible to view and print in table format and then save the results as an ASCII file (see Graphics).

The curves on the sheet labelled ”Weather Data” are available for selection with all systems.

A further selection depends on the type of system selected.

Details on the output values can be found under

Definitions

4.4 Payment Received for Grid Supply

This menu point is first activated after a simulation has been carried out.

The tariff forming the basis of the calculation is shown in the **Tariff Name** field.

Energy fed into the grid is shown separately for high and low tariff rates and for summer and winter.

The remuneration received for the electrical energy is provided on the basis of the tariff selected and the amount of energy exported to the grid.

The calculation results for the **Payment Received for Grid Supply** are printed in the Economic Efficiency Calculation.

4.5 Grid Electricity Costs

Here you are given a detailed list of variables for energy use under the headings: Kilowatt-Hours, Load and Discounts/Supplements, and the resulting costs (payments to the electricity utility). The values are given for two scenarios: **With PV System** and **Without PV System**.

Without PV System - the cost of electricity used is determined by the energy consumption of the electrical appliances.

With PV System – the cost of electricity used is determined by the amount of energy drawn from the grid.

Depending on the supply concept (see Tariffs), the energy used by the electrical appliances plus the energy used by the PV system itself is provided exclusively by the grid (**Full Supply**), or, with the **Own Use** concept, the amount of energy generated by the PV system must be deducted from this amount.

The name of the tariff on which the calculation is based is shown in the field at the top of the window. The tariff is defined under the menu point Conditions/Tariffs.

The results of the tariff calculation are given in a detailed table, divided into three sheets. A summary with the final result **Total Payment** is given in a field at the bottom of the window.

Kilowatt-Hours:

Specific Costs: Average specific costs in the given period.

Kilowatt-Hours from Grid: The number of kilowatt-hours of energy drawn from the grid in the given period.

Costs: costs before the deduction of discounts and the addition of supplements.

Payments: costs after the deduction of discounts and addition of supplements.

Load:

(see also the dialogue: Power Measurement).

Set Load Price: the set demand price as entered or the estimated price for wholesale provision of power to the utility.

Heavy Load Peak: for heavy/light load capacity measurement, the heavy load peak is given here.

Billing Load (Output Value): The output that is included in the billing calculation is given here, or, if a 96 hour tariff is in use, the output value is given.

Specific Load Price: Average specific load price in the given time period.

Consumption Dependent Load Price: billing load * specific load price.

Total Power Payment: represents the sum of the set and consumption dependent power prices after deduction of discounts and addition of supplements.

Discounts/Supplements:

Set Costs: The set costs defined in the Discounts and Supplements dialogue.

Hours of Full Utilisation: from quarter hour power measurement, the total hours of full utilisation and the resulting load utilisation period discount are provided.

Other Discounts, Supplements: the rebates and supplements entered in the ”Discounts and Supplements” dialogue are also shown here.

You are not able to enter values in this window.

4.6 Pollutant Emissions

This menu point is activated after simulation has been completed.

Here you can view the values for the pollutant emissions that have been avoided by use of the PV system.

The evaluation of pollutants varies for energy consumption and for energy provision to the grid.

With the ”Own Use” supply concept (see Tariffs) the energy supplied by the PV system replaces the energy from the grid. This is evaluated in the Pollutants dialogue in the column labelled ”Specific Pollutant Emissions per kWh of Electricity” for the electricity **consumed** by the appliances.

The electricity supplied to the grid by the PV system is also evaluated in the Pollutants dialogue, as a value of ”Specific Pollutant Emissions per kWh of Electricity” **avoided** by feeding the energy into the grid.

Emission values required for the calculations are entered under the menu heading Conditions/Pollutant Mix.

4.7 Project Report

4.7.1 Project Report

The results of the simulation are presented and can be printed out in the Project Report.

There is a one page Summary containing the most important simulation results and a multi-paged Detailed Project Report, that also contains the results of the Economic Efficiency Calculation.

4.7.2 Detailed Project Report

The Detailed Project Report is made up of three sections and can be viewed in preview (see Page Layout).

The first section gives the **System Data** for the PV system (System menu) and the appliances (Appliances menu). The types of modules and inverters used are given in the details for manufacturer, type, output and efficiency.

The system data can also be produced before simulation.

In the second section, the **Detailed Results** are presented. These basically consist of the Annual Energy Balance results plus a number of other results.

In addition, a graph illustrating the solar energy produced, the energy requirement and the supply of energy to the grid is provided. With the supply concept “Full Supply” the solar energy produced equals the amount of energy supplied to the grid.

In the third section the **Economic Efficiency** for stand-alone systems can be printed. If you want to change the parameters (investment, subsidy, interest etc) go to the Calculations/Economic Efficiency Calculation... dialogue. For grid connected systems, the Economic Efficiency Calculation can be printed from the Economic Efficiency Calculation – Grid Connected systems dialogue.

You can print the roof layout as a separate document via the menu: Results > Project Report > Roof Layout. This function is only active if the roof layout has been used in the project. Alternatively, you can select the detailed project report via the menu: Results > Project Report > Detailed Project Report, and then decide whether you want to include the roof layout in the detailed project report. If so, select the Roof Layout option.

All three sections can be printed separately. Click on the

button and a Print dialogue appears showing the sections that can be printed and the number of copies.

4.7.3 Print Dialogue

The standard printer is the printer selected in WINDOWS' system settings. If you want to print to another printer, go to the **Select Printer** dialogue by clicking on the **Settings** button.

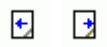
In addition, towards the bottom of the dialogue, you can see the **Subjects** that can be printed out. (Normally only one title is included.) At least one subject must be selected.

The number of copies that you want to print should also be entered in this window.

4.7.4 View Page Layout

This dialogue allows the page layout of documents that can be printed to be viewed before printing.

Where there are number of pages, you can move easily between pages:

- either click on the arrow buttons  in the menu bar, or
- or use the scroll bar on the right of the screen.

If there is only one page, no arrows are displayed.

When scrolling down a page (click on the black arrows in the scroll bar) the page will move to reveal any part of that page that is out of view, or the screen will move straight to the next page.

If the cursor is positioned within the area where it appears as a magnifying glass , the page being viewed can be enlarged or reduced. A ”+” in the magnifying glass means that the view area can be enlarged, and a ”-” means that the view area can be reduced. The area directly around the magnifying glass is enlarged.

Click on the printer symbol button to open the Print dialogue.

See also:

Detailed Project Report

Project Summary

4.7.5 Summary Project Report

This dialogue is a page preview (see Page Layout) of the one-paged project summary. This can also be printed out.

The **System Diagram** is shown. Each sub-array is allocated a PV symbol with details on the number, manufacturer and type of modules, the power output, tilt, orientation and type of mount. If the design includes multiple inverters the sketch will also include an inverter symbol for each sub-array, indicating the number, manufacturer, type and output. Depending on the supply concept selected (Own Use or Full Supply), the meter symbols are arranged differently. Values for the supply to grid tariff and the appliances' annual consumption are given as text with the appropriate symbol.

The annual results are basically the results of the Annual Energy Balance for the entire system. In addition, the level of CO^2 emissions avoided is given in the pollutant balance results.

4.8 Variant Comparison Selection

4.8.1 Variant Comparison Selection

In this window you can select the projects you want to compare in table format from the list of existing projects.

After the selection of systems has been made (not available with PV*SOL®-N for grid connected systems only), the projects will be shown together in a table – grid connected or stand-alone systems are grouped and listed separately .

A selection is made by marking the project required and moving it into the selection list.

Click on this button to select the projects. You can also drag and drop highlighted projects into the list.

With this button you can deselect projects from the list. Click on the field labelled **Current Project** to load the current project into the comparison table, provided it belongs to the selected system type.

Comparison Table

Click on **OK** to exit the dialogue and another dialogue opens in which the most important parameters and a summary of the simulation results are displayed.

The window has its own menu with the **Close** and **Copy** commands. The **Copy** command copies the table, so that the variant comparison can be pasted into external spreadsheet or word processing programmes for evaluation and printing out.

The dimensions produced are different for grid connected and stand-alone systems. The table headings, however, remain the same for both systems.

Table Headings

File Name: the file name is set when the project is saved. If the current project has been selected but not yet saved, the file name **Current Project** is allocated. Otherwise the file name is given without the directory path – eg Solar1.prj. The current project's file name is displayed at the top of the main screen.

Variant Reference: the project variant reference can be entered at the top of the main screen or is given as the file reference when saving the project.

Project Name: the name of the current project is entered in the first line of the "Project Administration" dialogue and shown at the top of the main screen.

Weather File: the weather data for the current project is also displayed at the top of the main screen. The weather file that was last loaded is used for all new system designs. The weather data can be changed via the **Conditions/Load Weather File** menu. Weather files have the file extension *.wbv.

4.8.2 Variant Comparison

The projects selected in the Variant Comparison... are set out in a table in this dialogue.

The most important parameters are shown, as is a summary of the simulation results.

The window has its own mini-menu with the **Close** and **Copy** commands.

The **Copy** command copies the table so that you can paste the variant comparison table into spreadsheet programmes such as EXCEL or into word processing programmes.

5 Quick Design

5.1 Quick Design

Quick Design allows a full system simulation to be carried out.

In addition to the entry parameters within the Quick Design dialogue, all other quantities are provided by the programme as standard values.

After simulation you are given a Summary Report. The Summary Report can be printed out on one side of A4 paper.

If you want to change the values entered in the Quick Design window and repeat the simulation, click on **<< Back**. Otherwise quit preview with **OK** and you can work on the project from the programme and then run a new simulation.

5.2 Quick Design – Stand-Alone Systems

When designing a stand-alone PV system with Quick Design, after selecting the weather file and entering values for the array orientation, you will have to define the consumption.

Click on the **Consumption** button to define the

Individual Appliances. From the Quick Design screen you are not able to define the consumption by load profile.

PV*SOL® makes a design recommendation according to the selected criteria: low, medium or high solar coverage, or depending on a chosen month of the year.

Click on the **Design** button and the required battery capacity and PV performance is shown. The desired system voltage needs to be selected, as does whether a back-up generator will be used.

After selecting the types of battery and PV module, click on **Sizing** to view details on the performance and capacity reached. If the batteries, modules and system voltage selected do not match up a message appears asking you to check the components or adjust the voltage.

The programme selects a system with one PV array and direct battery connection. Direct current appliances are presumed to be in use.

Click on **OK** to quit the dialogue and the adjusted values will be saved into your current project.

Click on the button **Save as Default** to save the values as a standard file. The next time you design a new project the Quick Design will open with these defaults.

With **Cancel** the previous conditions are reinstated. Click on

>> Simulation to start the simulation.

5.3 Quick Design – Grid Connected Systems

From the desired installed system power output and according to the selection of module and inverter types, the programme calculates both a suggested number of modules and inverters, as well as recommending module connections.

The programme default settings provide a system consisting of one array that can have a number of inverters. All the energy produced is fed into the grid, so the appliances do not need to be defined.

When you exit the dialogue with **OK** the amended values are saved as your base project and the next time you start to design a new project the Quick Design window will open with these defaults.

With **Cancel** the previous conditions are reinstated. Click on

>> Continue to start the simulation.

6 Technical Data

6.1 Technical Data

The technical data for the system configuration are entered in this dialogue, which is made up of a number of worksheets. The sheets used vary according to the system type (grid connected or stand-alone).

On the first sheet, labelled ”System”, you need to select the type of system – grid connected or stand-alone (not available with PV*SOL®-N for grid connected systems only).

For both types of system the **Number** of Arrays has to be entered.

The number of arrays is entered towards the bottom the page labelled ”System”. You can enter up to a maximum of six arrays.

A corresponding number of pages then appear in the **Technical Data** dialogue, so that you can define the parameters for each sub-array separately. With a single array the page is labelled ”Array”. A number of sub-arrays are labelled: ”Array 1”, ”Array 2” etc.

The other pages of the dialogue vary depending on the selected system:

Grid Connected und

Stand-Alone.

For details on the following button functions (located on the right hand side of the dialogue) go to:

Calculation Model/Losses

System Check

If the System Check is positive, you can click on the **Simulation** button to start the Simulation.

Click on **System Diagram** to view a System Diagram. This sketch forms part of the Summary Report.

6.2 Technical Data – Stand-Alone

6.2.1 Technical Data – Stand-Alone (not available with PV*SOL®-N for grid connected systems only)

With stand-alone systems you can select either **MPP Tracking** or **Direct Battery Connection**.

If you opt for MPP tracking you will have to select whether you want to employ one MPP tracker for the entire system or one for each array.

You will also have to select between **Direct and Alternating Current Appliances**.

With the use of AC appliances you will need to define a stand-alone system inverter on the worksheet labelled ”Stand-Alone Inverter”.

If you plan the use of a **Back-up Generator** a sheet is also provided for entering the parameters.

PV Array

Stand-Alone System Inverter

Battery

Charge Controller

Back-up Generator.

6.2.2 PV Array – Stand Alone

The settings on the page labelled ”Array” or, if a number of sub-arrays are being used, on the pages labelled ”Array 1”, ”Array 2”, etc, vary depending on the selected system operation.

Each PV array can be given a reference.

Click on the **PV Module** button to open the Load File dialogue and you can select from one of the database files provided. Tick the corresponding box and the module selected is used for all sub-arrays.

If the module you want to use isn’t included in the database, you will have to go to Database/PV Module and then enter the details. Then you can go back to ”Technical Data” and select your module.

When you exit the Load File dialogue with **OK** the parameters entered into the database are taken into the current project.

The **Full Data Record** for the module you have selected appears in an information window when you hold the cursor over the **PV Module** button.

The installed output for the array and the system output (see PV output on the ”System” worksheet) is calculated from the **Number of Modules**.

In selecting the **Number of Modules in a String** you will have to match the MPP tracking range or the battery voltage against the module’s MPP voltage.

If you want to use an MPP tracker in your system design click on the **MPP Tracker** button to open the MPP Tracking Characteristics dialogue. From here you can load or define an MPP tracker.

In order to convert the irradiation onto the horizontal surface, as given in the weather data, into irradiation onto the mounted PV array surface the Inclination and Orientation have to be entered.

You are also able to define single or double axis **Tracking** here. With **Single Axis Tracking** the programme works with a set inclination while tracking the sun’s azimuth angle. With **Dual Axis Tracking** the array is positioned so that the sun’s radiation falls vertically onto the array at all times. When the array is in a **Set Position** (ie with no tracking) both the tilt angle and the orientation have to be entered. With **Single Axis Tracking** only the tile angle has to be entered.

The resulting annual irradiation per square metre, taking shade into account, is shown under **Irradiation**. Click on the **Graph** button to view or print details.

Click on the **Max. Irradiation Inclination** button to find out the tilt angle required for maximum annual irradiation onto the array surface. With stand-alone systems the optimal inclination can deviate from the **Max. Irradiation Inclination**. The value appears on the button and can be accepted into the entry field. The current irradiation shown is dependent on this entry.

The Type of Mount can be selected from **Free-Standing**, **With Ventilation** space and **Without Ventilation** space.

The **Direct Current Cabling** to the charge controller is the cabling from the PV module string distributor to the charge controller. You can select from the standard **Cable Cross Section** measurements or enter your own measurement.

The losses from each individual module cable running up to the string distributor can be accounted for in the ”Calculation Model and Losses” dialogue.

If a number of cables are run to the charge controller, you should add the cross section measurement for each cable together.

6.2.3 Stand-Alone Inverter

If AC appliances are selected the system will need an inverter to convert the DC energy provided by the PV system into AC energy.

Click on the **Stand-Alone Inverter** button to open the Load File dialogue. If the inverter you want to use isn't among the files listed you should go to Database/Inverter**/**Stand-Alone and enter the required parameters.

Information on sizing is given in information fields (with a grey background). The inverter's nominal AC output should correspond to both the appliances' maximum power requirement and the battery's nominal DC voltage.

6.2.4 Battery

On the sheet labelled ”Battery” the type and number of batteries is defined.

Click on the **Battery** button to load a battery file from the database.

If the battery you want to use is not provided, go to the **Database**/Battery menu and enter the parameters.

The **Number** and the **Number in String** need to match the inverter’s nominal DC voltage and the MPP tracker or the module voltage.

If you plan to use a back-up generator you should enter 50% for the **Charge Condition at Simulation Start**, otherwise **Preliminary Simulation** should be marked to establish the charge condition (in this case the percentage figure is ignored). The previous year is simulated first, and the values from 31 December are taken as the starting point for 1 January of the year being simulated. This avoids any shift in the simulation energy balance where the battery reaches a charge condition after simulation that strongly deviates from the start value.

If the system uses a back-up generator the calculation of the correct start condition is not possible.

6.2.5 Charge Controller

Because of the large number of different designs, there is no database unit for special charge controllers in PV*SOL®.

On the ”Charge Controller” sheet an entry is made for the battery’s **Lower Discharge Threshold**.

For your information in regard to charge controller sizing, the short circuit current at 1000 W/m² and 50 C module temperature, and the appliances’ maximum electricity use are shown.

6.2.6 Back-up Generator

If the use of a back-up generator has been specified on the ”System” sheet, a sheet labelled ”Back-up Generator” appears.

The **Nominal Output** and the **Minimum Power Output** for the back-up generator need to be entered.

The **Fuel Consumption** is required in order to produce a figure for pollutant emissions and for the Economic Efficiency Calculation. The **Maximum Output - Appliances** and the **Total Battery Capacity** are shown for information.

A back-up generator that is required to always cover consumption during any shortfall of solar power must be able to deliver the maximum output required by the appliances (corrected by the battery charger efficiency rate). The generator modulates between minimum and maximum power output. With a single setting generator the minimum power output equals the nominal output.

For the **Battery Charger** you need to enter the AC/DC conversion **Efficiency**, the **Switch-on Threshold** (this should not be less than the battery discharge threshold – see ”Battery Charger”), the **Switch-off Threshold** and the **Switch-on Times** for loading the battery.

The back-up generator ensures a constant power supply to the appliances and that the lower battery discharge threshold is adhered to. If the back-up generator is switched on because the lower battery discharge threshold has been reached, it switches itself off only when the switch-off threshold is reached, provided that the timer is activated.

Because covering the energy load requirement has priority, the battery is also charged if the generator, because of its minimum power output, delivers energy in excess of that required to cover the load.

6.3 Technical Data – Grid Connected

6.3.1 Technical Data – Grid Connected

For grid connected systems you can choose between a system with a central **System Inverter** or a system with an inverter for each Arrayid_teilgenerator or with series or module inverters, ie with **Multiple Inverters**.

The **System Inverter** is selected on its own sheet in this dialogue. If you select a **Multiple Inverter** system you will need to enter the details for the inverters on each sub-array worksheet.

On the other page/s the PV Array or sub-arrays are specified.

In order to check the connection between the modules and inverters, and the influence of losses in the direct current cabling, you should click on the System Check button.

Click on the **System Diagram** button to view the System Diagram, that will later form part of the Summary Report. Each PV array is represented as a PV and an inverter symbol.

Technical Data

6.3.2 PV Array – Grid Connected

The PV array is specified on this worksheet.

You are able to give each array a **Reference**.

Click on the **PV Module** button to open the Load File dialogue. From here you can select a file from the database.

If your preferred module isn't listed, you will have to go to the **Database** menu and enter the details under PV Module. Then you'll need to go back to the **Technical Data** dialogue and select and load your module after clicking on the **PV Module** button.

Exiting the Load File dialogue with **OK** enters the parameters into the current project.

On the array sheet/s you also enter the **Number of Modules** . You can also define the number of modules in the **Roof Parameters Dialogue** from the available Roof Area.

The installed sub-array output and therefore the system output (see PV Output on the "System" worksheet) is calculated from the number of modules.

For the Type of Mount you'll need to choose between "**Free-Standing**", "**With Ventilation**" and "**Without Ventilation**". With Free-Standing modules, the required Minimum Distance between module strings is calculated in the **Roof Parameters** dialogue, in order to minimise mutual shading.

In order to convert the irradiation onto the horizontal surface, as given in the Weather Files, into irradiation onto the mounted PV surface, you have to enter the Tilt Angle and Orientation.

You are also able to define single or double axis **Tracking** here. With **Single Axis Tracking** the programme works with a set inclination while tracking the sun's azimuth angle. With **Dual Axis Tracking** the array is positioned so that the sun's radiation falls vertically onto the array at all times. When the array is in a **Set Position** (ie with no tracking) both the tilt angle and the orientation have to be entered. With **Single Axis Tracking** only the tilt angle has to be entered.

The resulting annual irradiation per square metre, taking shade into account, is shown under **Irradiation**. Click on the **Graph** button to view or print details.

Click on the **Max. Irradiation Inclination** button to find out the tilt angle required for maximum annual irradiation onto the array surface. With grid connected systems functioning under the full supply concept, the optimal inclination corresponds to the **Max. Irradiation Inclination**. The value appears on the button and can be accepted into the entry field. The respective irradiation shown is dependent on this entry.

Click on the **Inverter** button to load one of the available database files from the Inverter database.

If the **Set Fixed Configuration when Selecting Inverter** option is selected, only the inverters that match the number of modules in series are offered for selection in the load inverter file dialogue.

If the **Set Fixed Configuration when Selecting Inverter** option is **not** selected, all inverters are offered (in the load inverter file dialogue) which match any configuration. After selecting the inverter, a suitable configuration can be selected under **Configuration**.

The **Load Inverter** button is not visible if you have selected the System Inverter concept. In this case you load the inverter parameters from the **System Inverter** sheet. Likewise, the input field **Number of Inverters** only appears when you have selected the Multiple Inverters concept.

If you hold the cursor over either the **PV Module** or **Inverter** buttons an information window appears giving the full data record details for the chosen PV module or inverter.

Configuration per Inverter

After selecting the inverter, you enter the Number of Modules in Series and, if required, the Number of Inverters onto the sub-array sheets. Under **Configuration**, all of the configurations that are technically possible are shown, taking into account the permitted values for current and voltage.

If the **Set Fixed Configuration when Selecting Inverter** option is selected, all of the mathematically possible module configurations per inverter are shown.

If a multi-string inverter with multiple independent MPP trackers is selected, it is possible to enter the configuration for each MPP tracker separately in the **Define Multi-String Configuration** dialogue.

For the **DC Cabling** to the inverter, the programme calculates the wiring from the PV module string distributor up to the point of entry into the inverter.

Standard **Cable Cross Section** measurements can be selected or you can enter your own measurement.

You can account for general losses from the cabling running from the individual modules to the string distributor in the Technical Data/Calculation Model/Losses dialogue.

6.3.3 Number of Inverters

The number of modules per inverter is determined by the number of modules divided by the number of inverters.

Because the programme only allows a symmetrical connection, the number of modules per inverter must be equal for all the series in an array.

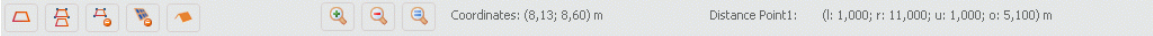
An automatic system check takes place on quitting the dialogue with **OK**. The following error dialogue could appear:

The number of modules must be a multiple of the number of inverters.

In setting the number of inverters you should ensure that the installed power capacity for the modules and inverters match.

6.4 Roof View

6.4.1 Toolbar



The toolbar contains the buttons listed below. The current cursor position is also displayed under "Coordinates", which allows you to find the position of an object point, for example.
The area of the toolbar to the right shows the distance of a selected barred area point or PV area point from the outer borders of the roof area.

6.4.1.1.1.1 *Create a New 2D Object*

The "Create a New 2D Object" button opens the New 2D Object dialogue. Here you can define new roof areas, barred areas or PV areas.

6.4.1.1.1.2 *Copy 2D Object*

Once you have selected a barred area or a PV area you can copy this to the clipboard by clicking the "Copy 2D Object" button (or pressing CTRL+C). You can then paste the copied barred area or PV area into your roof area by right-clicking and selecting the Paste command (or pressing CTRL+V).

6.4.1.1.1.3 *Delete 2D Object*

Click the "Delete 2D Object" button (or press the Delete key) to delete selected barred areas, PV areas, modules or module formations.

6.4.1.1.1.4 *Delete All PV Areas*

Attention! Clicking the "Delete All PV Areas" button deletes all the PV areas.

6.4.1.1.1.5 *Delete All 2D Objects (except roof)*

Clicking this button deletes all the 2D objects except for the roof area.

6.4.1.1.1.6 *Enlarge view*

This button enlarges the view of the roof area.

6.4.1.1.1.7 *Reduce view*

This button reduces the view of the roof area.

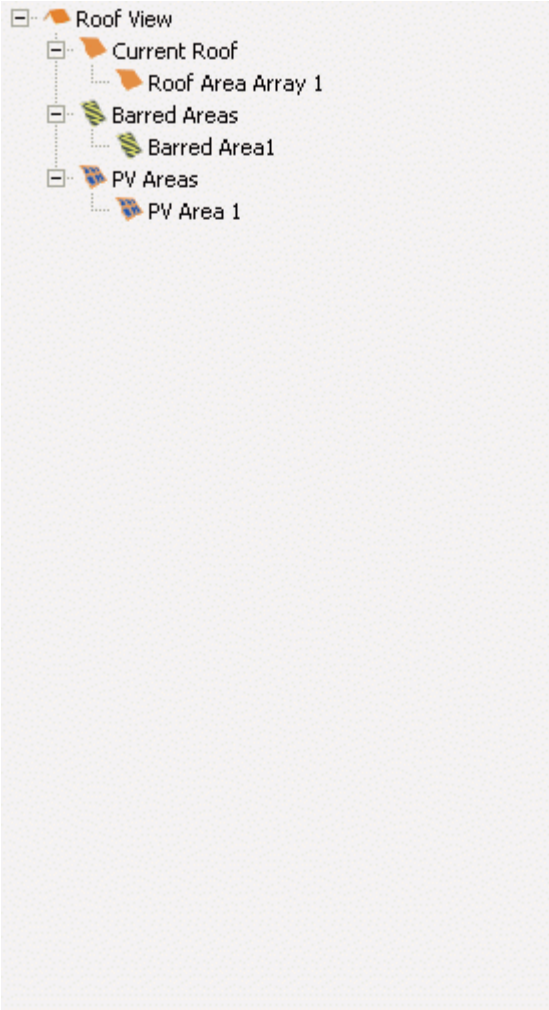
6.4.1.1.1.8 *Zoom - Select Best View*

Clicking this button sets the optimum zoom factor.

6.4.2 Tree view

The tree view gives you an overview of the 2D objects that are used in your PV system.

Left-click on an element in the tree view to select the 2D object. Right-click on a 2D object in the tree view to open a pop-up menu with all the available commands for the selected 2D object.



6.4.3 Roof visualisation

You can print the roof layout as a separate document via the menu: Results > Project Report > Roof Layout. This function is only active if the roof layout has been used in the project. Alternatively, you can select the detailed project report via the menu: Results > Project Report > Detailed Project Report, and then decide whether you want to include the roof layout in the detailed project report. If so, select the Roof Layout option.

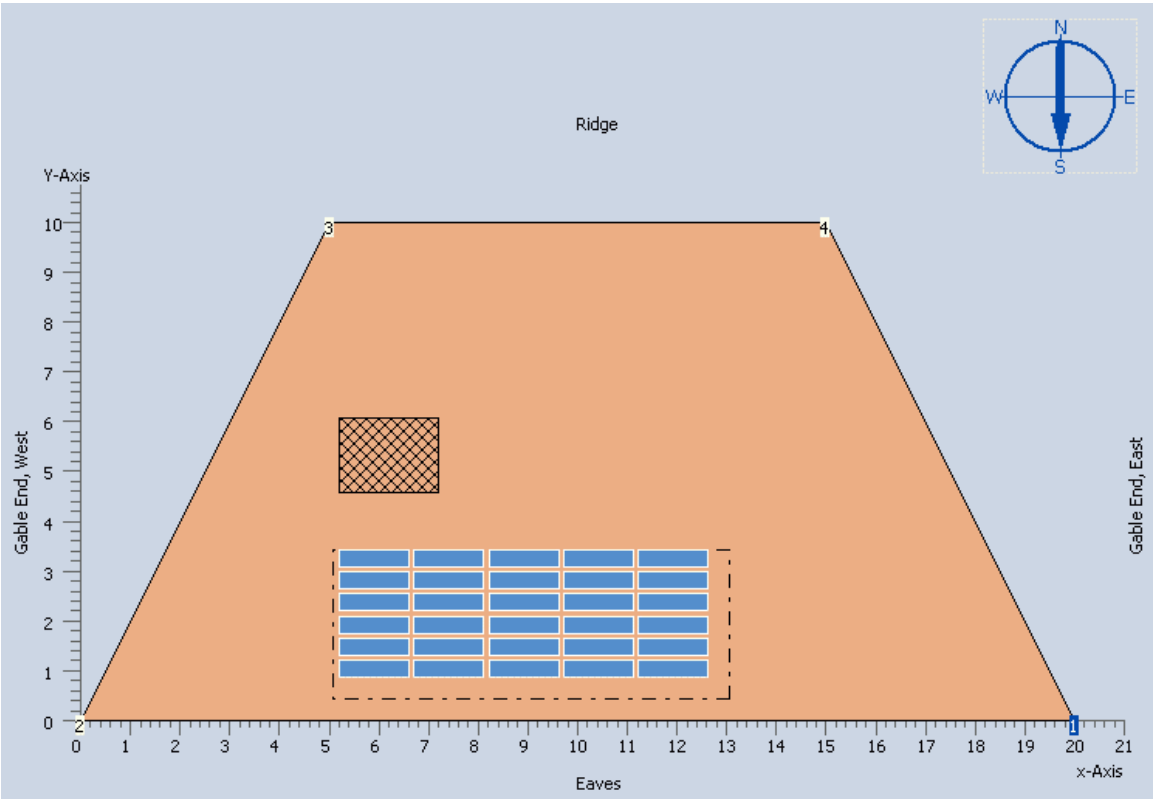
The roof visualisation shows your current roof project including the PV areas and barred areas.

- You can drag and drop PV areas and barred areas to move them.
- If a 2D object is selected, its corner points are shown and can be edited in the input field.
- The compass rose at the top right of the image is available for projects with mounted PV modules. It shows the direction that the roof faces.

The following keyboard shortcuts are available when you are editing the module formations:

- CTRL + left mouse key: Multiple selection
- SHIFT + left mouse key: Row selection

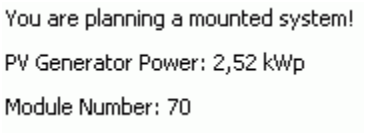
- ALT + left mouse key: Column selection



6.4.4 Messages

The messages area shows you the following information:

1. Type of installation
2. PV generator power
3. Number of modules

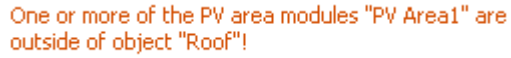


Messages about any conflicts in the roof coverage are also displayed here.

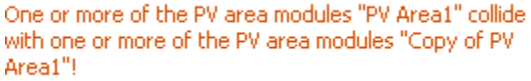
1. No conflicts exist.

2. A PV area overlaps with a barred area.

3. At least one module in a PV area is located outside the roof area.

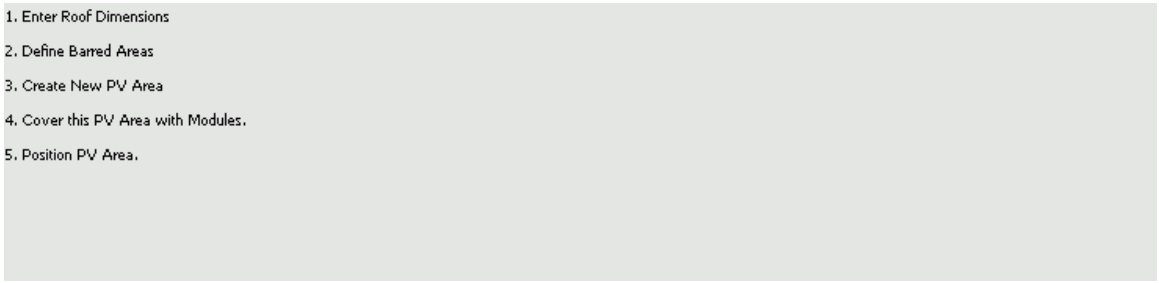
4. The modules of various PV areas overlap.

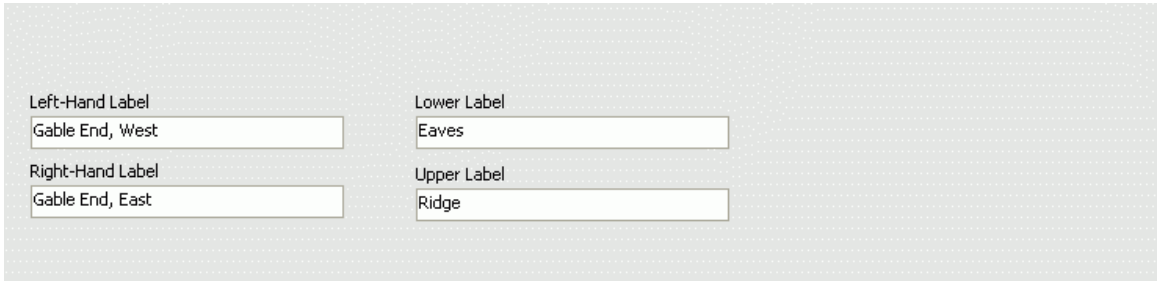
6.4.5 Input field

The appearance of the input field varies depending on the type of object that is selected in the tree view.

When "Roof View" is selected, an overview of the workflow appears.

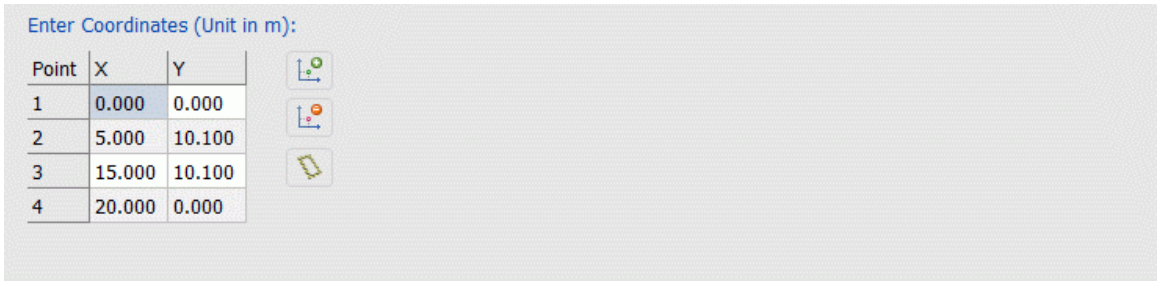


By selecting "Current Roof" you can rename the roof boundaries that appear in the roof visualisation.

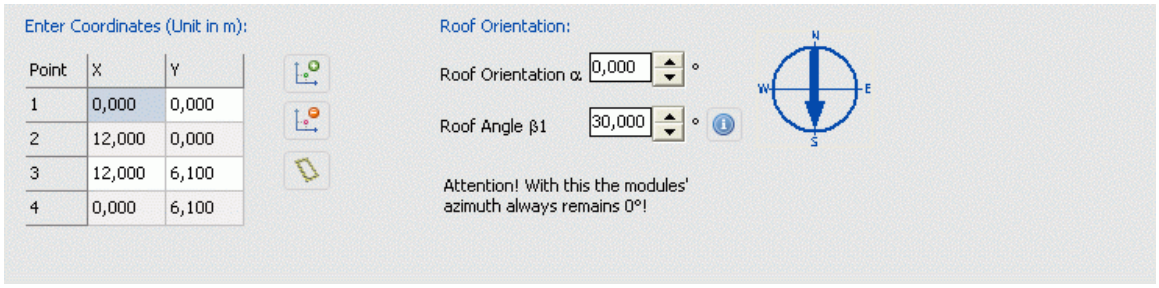


By selecting the roof object (default: "New Roof") you can edit the coordinates of individual points of the selected object. You can use the buttons to add or remove points from the selected roof object.

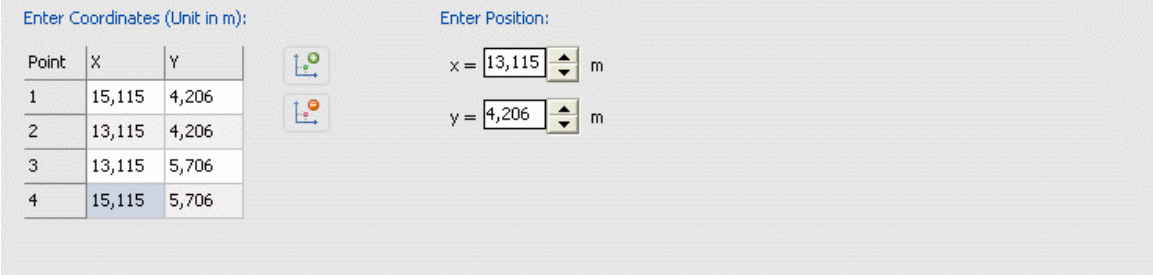
Click the button to open the Edge Distances window.



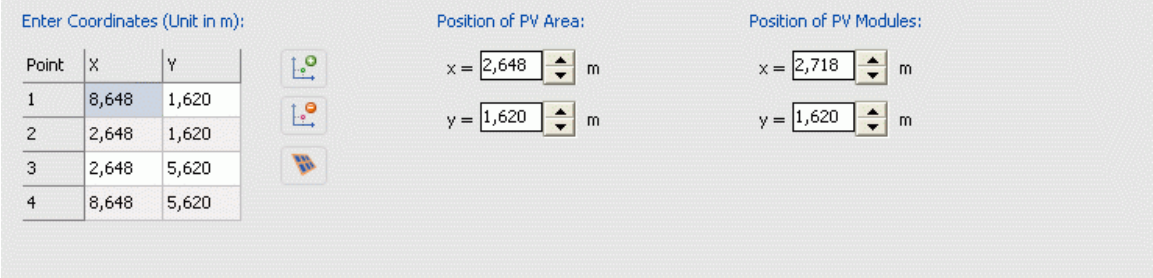
If you are planning a mounted PV system, you can also enter the roof orientation and the roof angle.



By selecting a barred area object (default: "Barred Area 1") you can edit the coordinates of individual points of the selected object.
Under "Enter position" you can enter the position of the entire selected object.



By selecting a PV area object (default: "New PV Area") you can edit the coordinates of individual points of the selected object.
Click the button to open the Module Coverage dialogue.

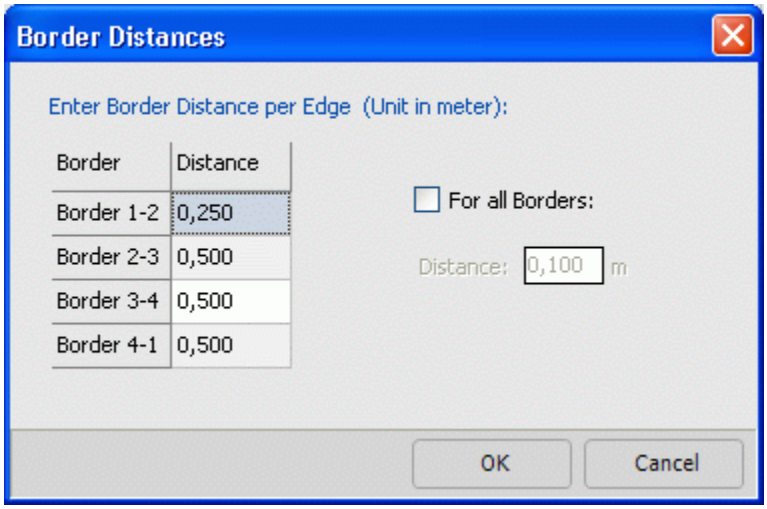


6.4.6 Border Distances

In the "Border Distances" window you can specify barred areas of a certain width for the borders of your roof.

To open the "Edge Distances" dialogue: In the tree view select the roof area and in the input field click the "Edge Distances" button . Alternatively you can right-click on the roof area in the roof visualisation or open a pop-up menu in the tree view and click on "Edge Distances".

- If you want to define equal border distances for all the boundaries of your roof, then use the option "For all Borders" on the right-hand side of the window.
- In the left-hand area of the window you can specify individual border distances for each border of the roof.



6.4.7 New 2D Object

6.4.7.1 New 2D Object

The "New 2D Object" dialogue lets you define new 2D objects for your project. First of all, select the type of the new 2D object in the drop-down menu at the top left. Then enter a name for your new 2D object where it says "Reference", or let PV*SOL name the object for you.

Depending on the object type you selected, various different options are now available for defining the new 2D object. For more information, click on one of the three links below.

- New roof area
- New barred area
- New PV area

6.4.7.2 New roof area

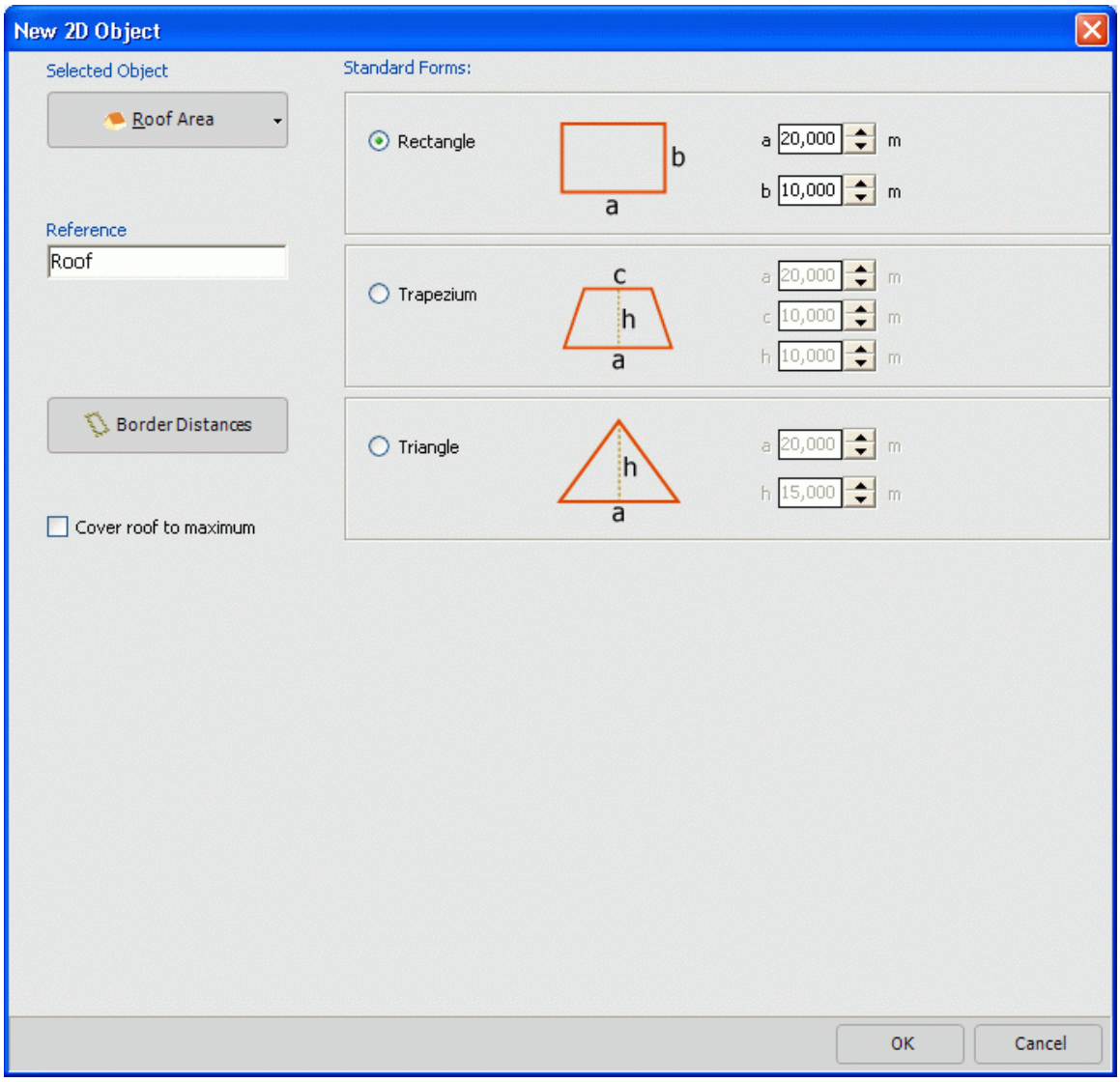
Various geometric shapes are available for designing a new roof area:

1. Rectangle
2. Trapezium
3. Triangle

Click the

button to open the Edge Distances window where you can specify barred areas for the borders of your roof.

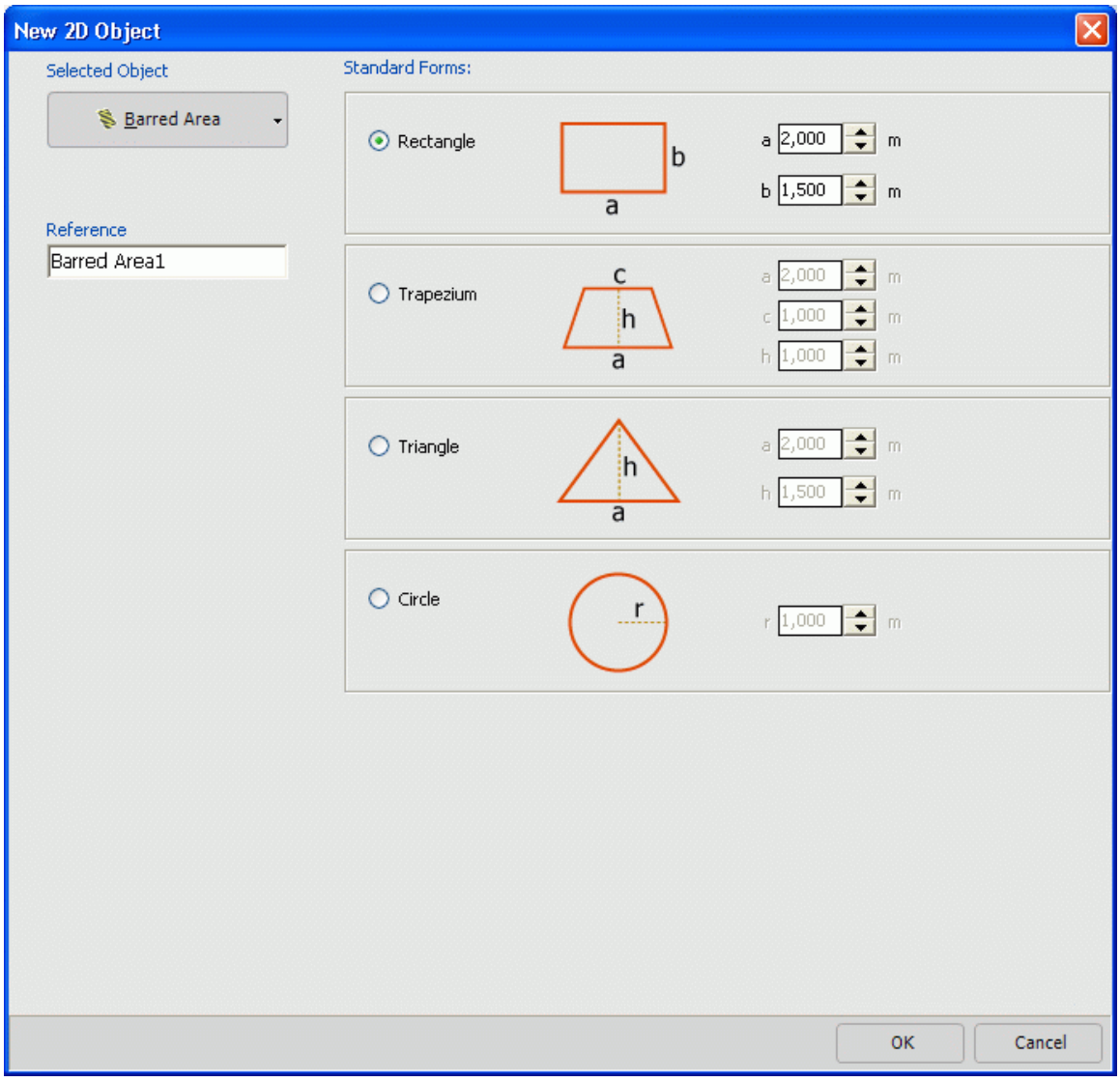
Tick the "Cover roof to maximum" box to give the new roof area a PV area the same size as your roof. PV modules will then be added automatically when you click on "OK".



6.4.7.3 New barred area

Various geometric shapes are available for designing a new barred area:

1. Rectangle
2. Trapezium
3. Triangle
4. Circle

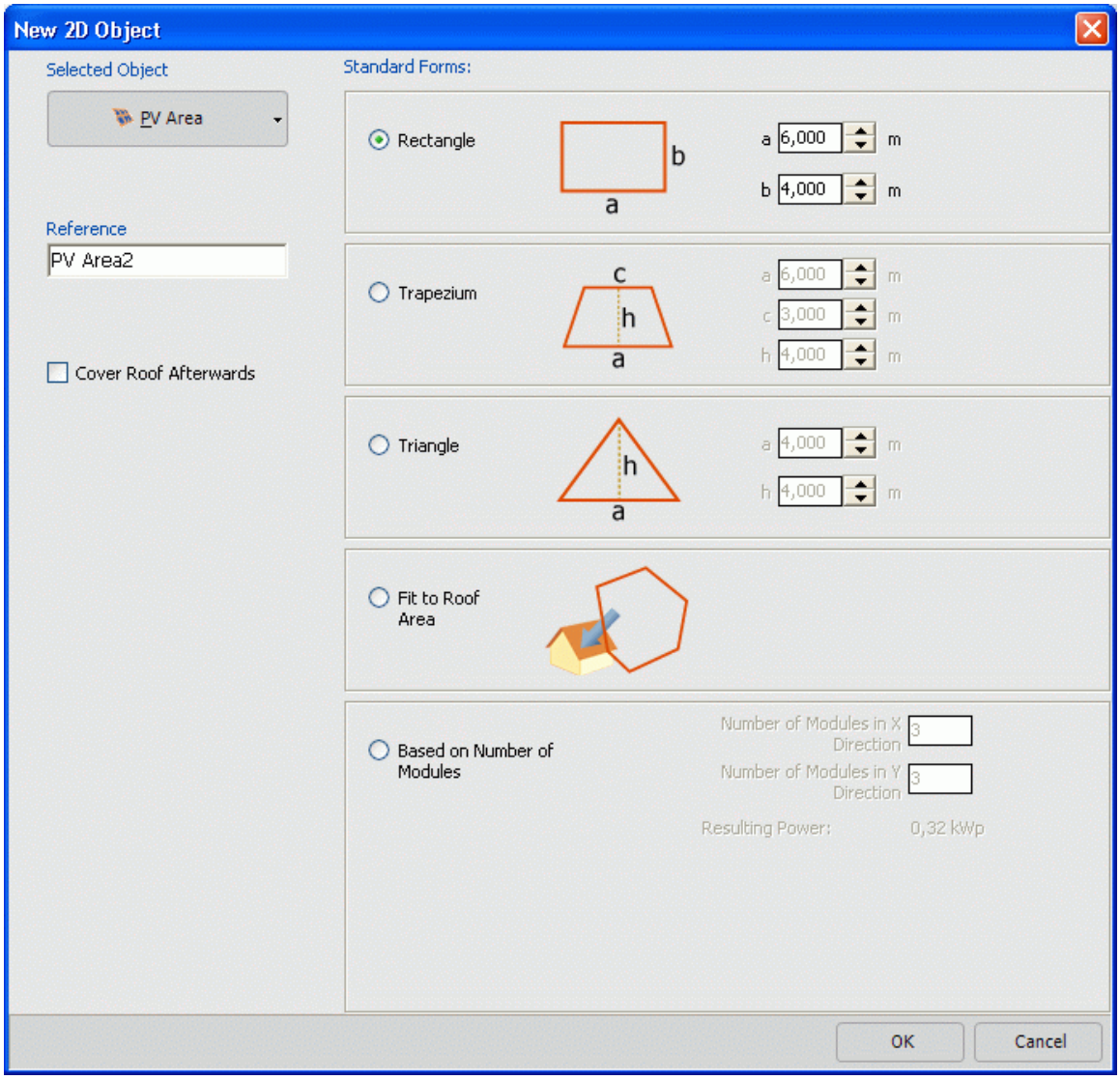


6.4.7.4 New PV area

Various geometric shapes are available for designing a new PV area.

1. Rectangle
2. Trapezium
3. Triangle
4. Fit to roof area
   The new PV area takes the shape and dimensions of the existing roof area.
5. Based on number of modules
   The size of the new PV area is determined for a specified module formation. Enter the number of rows and columns in the planned module formation.

Tick the "Cover roof afterwards" box to add PV modules to the new array area automatically after you click on "OK".



6.4.8 Module coverage dialogue

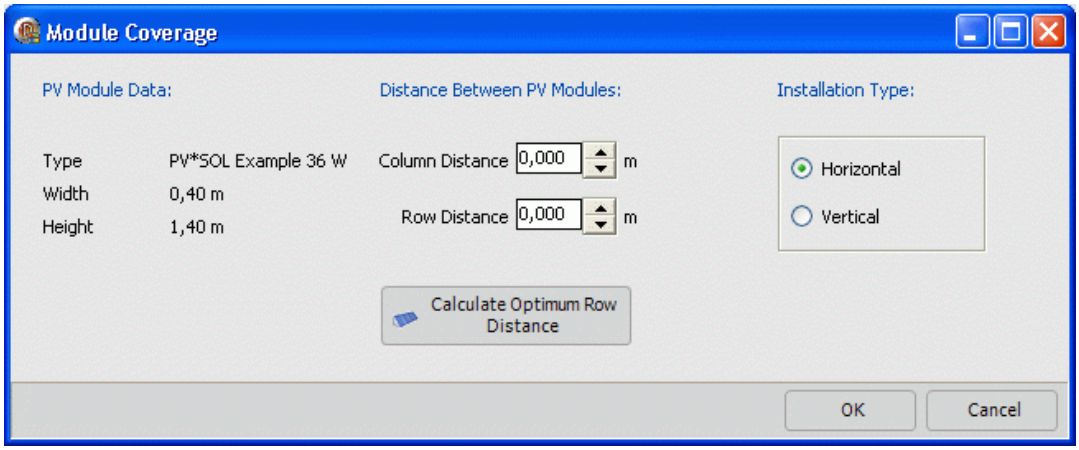
6.4.8.1 Module coverage dialogue

- To open the "Module Coverage" dialogue: In the tree view, select a PV area and click in the input field on the "Edit coverage" button . Alternatively you can right-click on a PV area in the roof visualisation or open a pop-up menu in the tree view and click on "Edit coverage".

- The "Module Coverage" dialogue lets you specify the column distances and the row distances for the PV modules. The minimum distance for both values is 0.05 m = 5 cm.

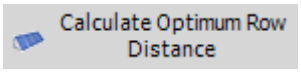
- Under "Installation type" you can specify the module orientation (horizontal or vertical).

- The Calculate Optimum Row Distance command is only available for mounted PV systems (Installation type: Free-Standing). By finding the optimum row distance you can minimise mutual shading caused by mounted module rows.

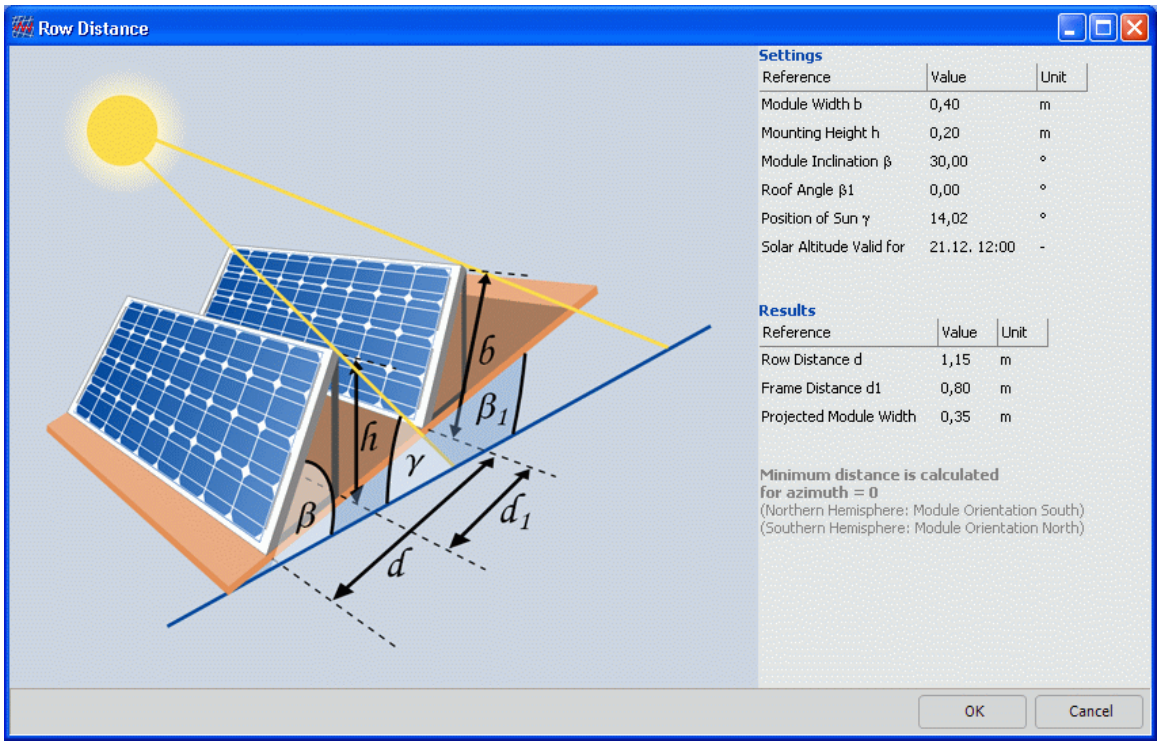


6.4.8.2 Calculate Optimum Row Distance

For mounted PV systems (Installation type: Free-Standing) you can calculate the optimum row distance. This minimises mutual shading between rows of mounted modules.

To open the "Row Distance" dialogue, open the Module Coverage dialogue and click on 

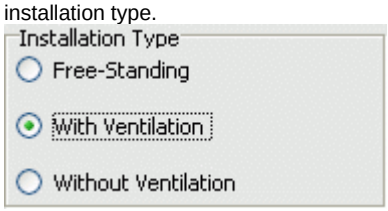
.



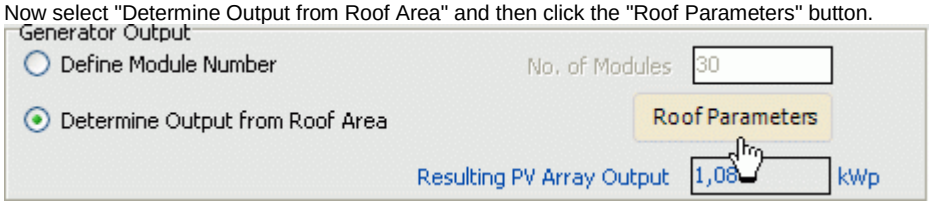
6.4.9 Workflow

Example for a PV system with ventilation.

1. Specify the installation type: In the "Technical Data: Array" window select "With Ventilation" as the desired installation type.

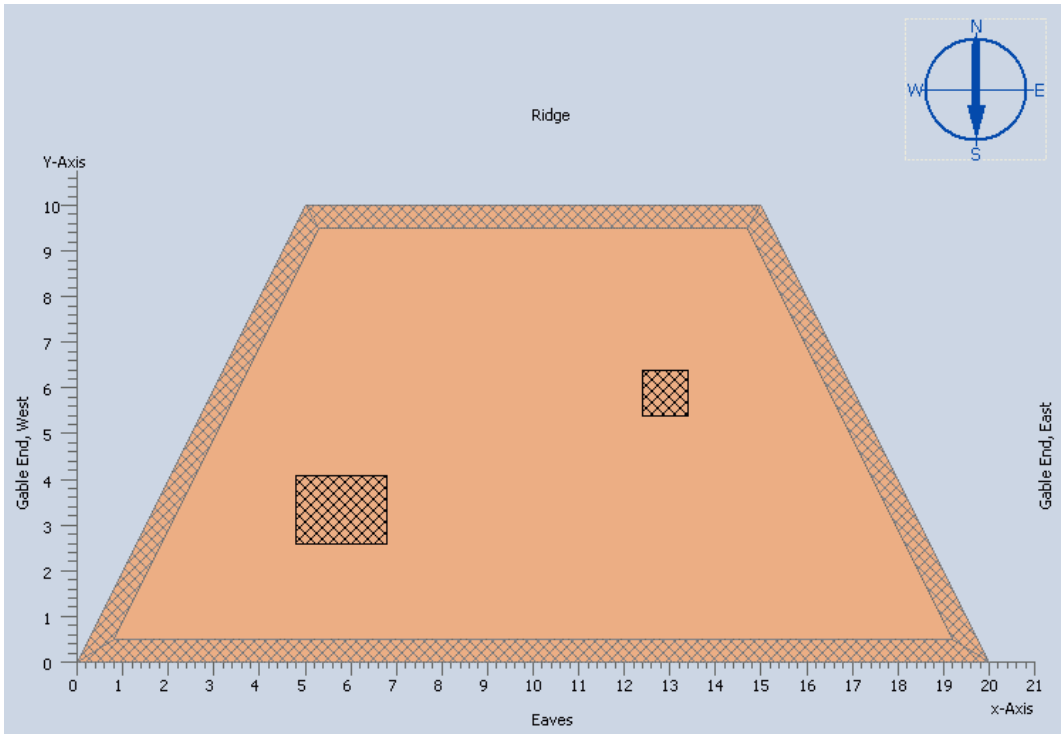


2. Now select "Determine Output from Roof Area" and then click the "Roof Parameters" button.

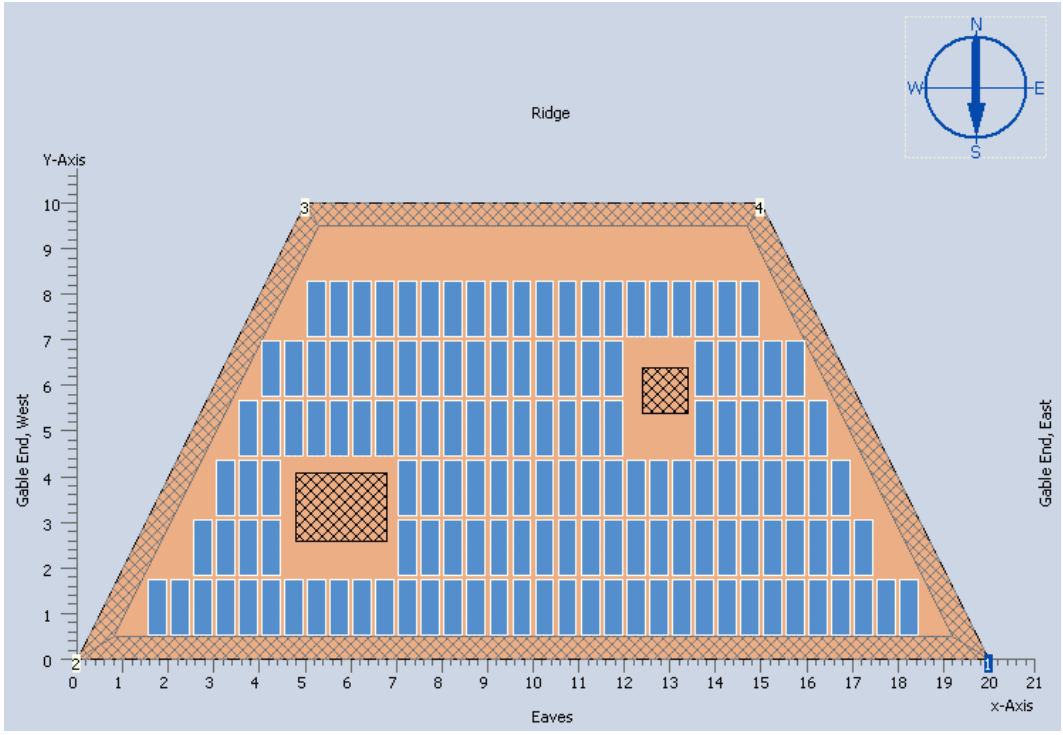


3. Specify the size of your roof area. To do this, select the roof area by left-clicking on the roof area in the roof visualisation or select your roof area in the tree view (default: New Roof). You can now specify the size and shape of your roof in the input field.
4. First of all, delete all 2D objects by clicking the "Delete All 2D Objects (except roof)" button . Alternatively you can delete particular 2D objects by clicking the button, for example to obtain a barred area that you require.
5. Specify the barred areas for the borders of your roof area. To do this, select the roof area by clicking on the roof area in the roof visualisation or select your roof area in the tree view (default: New Roof). Now in the input field click on the button and define the required barred areas in the Edge Distances dialogue.

6. Now create a new barred area (e.g. skylights and chimney). Your roof might look something like this:



7. To define a PV area that is matched to the roof area, click the "Create a New 2D Object" button to open the New 2D Object dialogue. Make sure that "PV Area" is selected in the drop-down menu at the top left and select the "Fit to roof area" option for the new PV area. Now tick the "Cover roof afterwards" checkbox and PV modules will automatically be added to the roof area when you click "OK". Now your roof might look something like this:



8. Now you can specify the installation type (horizontal or vertical) and the distances between the PV modules in the Module Coverage dialogue.

6.5 Orientation

The **Inclination** (Tilt Angle) represents the angle between the horizontal and the collector surface. It is 0° when the module is laying flat on the ground and 90° when standing upright.

The **Orientation** (Azimuth) represents the angle of deviation of the PV surface from the south in the northern hemisphere and from the north in the southern hemisphere. It is 0° when the surface is facing towards the sun's highest point (zenith).

PV*SOL recognises from the weather data, which contains the degree of latitude, whether the system is located in the northern or southern hemisphere.

The azimuth is positive when facing west and negative when facing east. An orientation due west corresponds to a value of +90° and an orientation due east is -90°.

From the inclination and orientation the radiation processor calculates the irradiation onto the tilted surface. Click on the **Graph** button to view the annual irradiation fluctuations [kWh/m²] and the annual radiation duration curve [W/m²].

6.6 Type of Mount

The type of mount influences the heating of the PV modules.

With a **"Free-Standing"** mount the entire module surface (front and back) exchanges radiation with its environment.

For a roof-top mount **"With Ventilation"** only the upper module surface is available for radiation exchange, and for roof-top or façade integration **"Without Ventilation"** this is reduced further. With roof or building integration the output is reduced further by a lack of convection.

High module temperature leads to a drop in module efficiency. Yields for PV systems with free-standing mounting are therefore higher than those for systems with ventilation space which in turn have higher yields than systems without ventilation space.

6.7 Define Output Losses

Here you are able to define power loss in the PV modules caused by ageing.

Enter the annual **Output Losses** as a percentage of the nominal output (power rating). In the **Remaining Output** column you will then see the resulting output as a percentage of the nominal output. The **Output Losses** defined first take effect at the end of a period, ie losses for the first year first come into effect in the second year, etc. After 10 years, the power output of the PV module remains constant.

If you wish to allow for deviation in the first year of the PV modules' actual output from the nominal output, then enter this figure in the field labelled **Deviation of Module Output from Nominal Output**.

6.8 Module Part Load Operation

The module's operation under part load conditions is calculated from the specifications for no-load voltage, short circuit current, MPP voltage and MPP current with low irradiation and a module temperature of 25°C.

The second working point, ie the choice of irradiation level, has to be set under certain restrictions. It must be selected so that, at the irradiation point set, the fill factor is at maximum, or so that, with lower irradiation, the fill factor becomes considerably smaller and with higher irradiation the fill factor is around the maximum value.

The definition of the fill factor is:

FF = (MPP current * MPP voltage)

/ (short circuit current * no-load voltage)

The fill factor (FF) is dependent on the irradiation. If a FF above the irradiation is applied, this results in the fill factor function. Depending on the module and the irradiation, the FF is usually set at around 55% and 85%.

If you don't have any suitable specifications for part load operation, you can run the calculation with standard values by clicking on the **Typical Part Load Operation** button.

For most modules, the irradiation at the fill factor maximum is 300 W/m². The fill factor is set at 5% above the FF under standard test conditions. Linear part load operation is given for the current.

After you have entered the values for module part load operation, it is essential to take a look at the efficiency characteristic curve and to test that there are no discrepancies.

6.9 PV Array/Sub-Array

A PV array/sub-array is a PV surface unit made up of the same types of module mounted together and set at the same angle and orientation. If you have a number of inverters connected to an array, these also have to be all the same type.

6.10 Calculation Model and Losses

The array's power output (DC side) is, along with the STC efficiency and the calculated output, determined by the part load operation, the output's temperature dependency (see output coefficient in the PV Module dialogue) and the additional losses.

Losses occur during real system operation:

- due to deviation from the standard spectrum AM 1.5,
- due to mismatch or lesser yield due to deviation from the manufacturer's data
- in the diodes, and
- due to pollution.

Deviation from Standard Spectrum AM 1.5:

Spectral mismatch changes the module's characteristic curve, which is measured against a standard spectrum. In Central Europe a correction factor of an annual average of 2% can be allowed for. The correction factor should be entered in the field provided.

Mismatch or Lesser Yield Due to Deviation from Manufacturer's Data:

Despite equal irradiation and temperature, different MPPs (mismatching) can occur because of production tolerances, or because the modules do not reach their full power as stated by the manufacturer (lesser yield). These kind of power losses can reach 1-5%. (This does not mean the "mismatch effect" that occurs if differently aligned modules, ie a number of sub-arrays, are connected to a single system inverter. These losses are defined during simulation.)

Diodes: Losses caused by a drop in voltage by the modules' blocking diodes can usually be ignored.

Pollution: Over a certain tilt angle (approx. 20%) losses caused by pollution can be ignored.

Ground Reflection (albedo) is evaluated in the radiation processor. PV array irradiation is increased by the reflection of radiation on the ground or in the surrounding area. With a ground covering of snow the albedo is 80%, under normal conditions the albedo is 20%.

Allowing for Manufacturer Tolerances in Pre-Graded Sub-Arrays

If the module output (power rating) deviates from that specified by the manufacturer, you are able to take this into account here. This, for example, makes sense when you have pre-sorted the modules according to power output.

From the **System Height** above ground level it is possible to determine the scalar wind at system height for the dynamic Temperature Model. The wind in the weather data is measured at a height of 10 meters.

6.11 System Diagram

The System Diagram is a coloured sketch of the system. This will later form part of the Summary Report.

System components such as arrays, inverters, batteries, and also the consumption as well as the grid concept are illustrated as symbols. Important details, such as the number and type of modules or inverters, are also shown.

The System Diagram is a sketch. It cannot be edited and does *not* represent a full technical drawing of the system.

6.12 Photo Plan

Using Photo Plan, you can create a photorealistic plan of your roof areas. With just a few entries on the geometry of the roof, it is possible to gain an impression of the future look of the roof areas. You require only a photo of the roof.

In addition, Velux® skylights and Braas® roof tiles can be included and displayed.

Before

After

7 Weather Files

7.1 Weather Files

With the **Conditions/Load Weather File** menu command you open the Load and Save dialogue, from which you can load the weather file for the project location or the site closest to the project location. The files (eg London.wbv) contain values over a one year period for global radiation, external temperature and scaled wind speed in hourly format.

The current project weather file location appears on the main screen in the area containing the project details (underneath the menu bar). When you start a new project design the weather file used in the previous project is automatically loaded into the new project.

The weather data have been calculated from monthly mean values over a ten year period, enabling a weather generator to produce a characteristic hourly sequence.

It is possible to load weather files from the German Weather Service in the form of test reference years (file ending **.try).** The data required by PV*SOL will be automatically selected.

It is also possible to convert weather data from METEONORM Weather Data Records.

Weather data can be viewed in graph format before and after simulation with the menu command **Results/Energy and Weather Data...**. Wind data is only evaluated when the “Dynamic Temperature Model” is selected under **Options/Settings/Calculation Model**.

The irradiation onto the (tilted) PV surface, combining diffuse and direct radiation, is generated from global radiation.

The ground reflection (albedo), entered in the **Technical Data/Calculation Model/Losses** dialogue, is accounted for as a diffuse radiation gain.

The radiation reflected off the module surface is accounted for as a reflection loss. After simulation you can view this data in diagram format under **Results/Energy and Weather Data...**. The details are divided into radiation onto the tilted PV array surface and radiation minus reflection and are shown in W/m².

Reflection losses on the module surface lead to a decrease in the module’s efficiency.

7.2 Converting METEONORM Weather Data

With the Swiss programme METEONORM (available from Valentin Energy Software) you can convert worldwide weather data for use with PV*SOL.

From Version 4.0 onwards it is possible to produce user defined data.

In order to convert METEONORM files into PV*SOL® weather data, you should select **T/PVSOL** under **Output Formats** for the required hourly format.

After you have produced the hourly values for your site in METEONORM, save the values to file with the ending *.dat. Ideally you should save into your current PV*SOL® weather folder (eg: c:\pvsol\database\weather).

Conditions/Load Weather File or the button opens a dialogue window in which you can select the Meteonorm (*.dat) file type. Weather data produced in METEONORM can then be selected and loaded into your PV*SOL project.

7.3 Load Weather Data File

From this dialogue you can select an appropriate weather data file. If you have installed weather data for a number of countries, you can pre-select the files available for each country in the **Country Selection** field - then only the locations for the selected country are shown. Click on a column heading to sort the database from this column. Click on the same column heading again to change the sort direction.

The column heading selected to sort the database is marked with a blue arrow pointing in the sort direction. Enter the first character of the text you want to get to in the sorted column and you will jump to the first entry with this character.

The complete file path for the selected file is shown in the lower status bar.

If, as an exception, you want to load a weather data file from another directory, eg from a network or disk, click on the **Load Data Dialogue** button. If you want to load your weather files from another directory on a permanent basis, we recommend that you change the standard file path under Options/Drives….

8 Shade

8.1 Shade

Entry of the shade parameters in the programme is in two stages. You are able to define the horizon and middle-distance objects (see Shade from Individual Object).

The Azimuth angle is the deviation from south, as in the ”Technical Data” dialogue. Due east is entered as -90° and due west as +90°.

Middle-distance objects means objects that need to be taken into account in the calculation, because the PV array is fully shaded by these objects at certain times of the day.

The entries for shading from the horizon and middle-distance objects reduces the irradiation onto the array surface, and a correction factor enables the programme to simulate the shade moving over the array.

The programme allows a sketch of the horizon parameters to be made using the mouse. Values are given at the bottom of the window, as is the following message:

To start the sketch click on New Sketch or click on the horizon line with the left mouse button.

New Sketch

Adding a vertical to the existing horizon line can be difficult. This is better done by entering an individual object. Click on **Object List** to open the Shade from Individual Object dialogue.

You can make a new sketch of the horizon at any time.

Another method is to enter the horizon parameters into the

Table.

If you have a system with a number of arrays not only is each of these given its own page in the **Shade** dialogue, but there is also a button labelled **All Arrays**.

Click on **All Arrays** and the parameters for the horizon currently on screen are adopted for all of the sub-arrays. The individual objects are, however, not adopted.

Save the shade parameters to file or load an existing file in order to use horizon or individual object parameters again.

8.2 Coordinates Table

Another method of entering the horizon is to enter the values into the horizon coordinates table. The start and end points are already entered, as are any coordinates you have drawn with the mouse in the sketch.

Any new points are added to the table in consecutive order. Click on **New Point** to define a point and on **Add Point** to add the values to both the table and the sketch.

Any points in the table can be deleted by first clicking on them (so that they are highlighted in blue) and then clicking on the **Delete Point** button.

8.3 New Sketch

Click on the **New Sketch** button and the cursor is represented as a pencil symbol. As soon as you move the cursor over the sketch area a line is drawn between the starting point and the cursor position. The actual cursor position is shown at the top of the dialogue.

The position of the line is accepted by clicking on the desired end position within the sketch area. The horizon sketch is always drawn from left to right. If you move left of a starting point the cursor changes into a warning hand and a line is no longer drawn.

If you want to interrupt the sketch click with the right mouse button. This message also appears at the bottom of the dialogue:

Click with right mouse button to end sketch.

If you want to rework any lines you have drawn, you can only do this after the current sketch is complete, as per the message given at the bottom of the sketch:

To rework the horizon click on the horizon line with the left mouse button.

8.4 Shade Caused by Individual Objects

In addition to shade from the horizon (see also section on Shadeid_verschattung) the programme also allows definition of individual objects that shade an array.

The objects already defined are found in the **List of All Objects**. From the left hand side of the window you can select the object whose value you wish to see or change. If no object has been defined, the list is empty.

Next to the object reference in the top right of the window, a corresponding illustration of the type of object, tree or house, appears when a selection is made.

If you want to define a new object click on **New House** or **New Tree**, according to the type of object causing the shade. A new object (eg with the reference No. 1) is created and the standard values appear on the right of the window.

The difference between a tree and house is the extent to which the object allows light through. On selecting a new tree the **Seasonal Shade** button is activated and you are able to enter a percentage figure for each month of the year. In summer the shade from the leaves of a tree will be 90%, in winter this figure will be more like 40%.

Objects can be deleted from the list by highlighting the object in the list and then clicking on the **Delete Object** button.

The specifications from which objects in the vicinity can be defined are: height, width, distance and azimuth.

The point of measurement for setting these dimensions is the middle point of the array surface, facing south. Therefore an azimuth of 0° means that the object is positioned to the south, independent from the PV array's actual azimuth.

The elevation angle is defined from the specification of the height and distance. Width and azimuth represent the object's angle coordinates.

The calculated dimensions (fields with grey background) are first calculated on leaving the object, and the values are updated when the values are loaded again.

9 Economic Efficiency Calculation

9.1 Economic Efficiency Calculation…

After simulation it is possible to carry out an **Economic Efficiency Calculation**.

The **Economic Efficiency Calculation** follows the net present value method.

The entry dialogues and the dimensions calculated are different for stand-alone and grid connected systems.

Economic Efficiency Calculation – Grid Connected Systems

Economic Efficiency Calculation – Stand-Alone Systems

9.2 Payback Period

The period required to get to the point when the net present value of the investment first becomes positive.

9.3 Net Present Value

The **Net Present Value** is calculated from the:

- Cash Value of all Annual Costs
- Cash Value of all Annual Lodgements and Savings
- Cash Value of Loan Payments
- Cash Value of Tax Payments
- One-off Payments
- Subsidies
- Self-Financing

9.4 Economic Efficiency Calculation - Other Proceeds/Savings

Here you can define any **Other Annual Proceeds/Savings**.

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

The **Price Change Factor** indicates the average percentage change of a payment in comparison with the previous year.

9.5 Electricity Production Costs

The **Electricity Production Costs** are the annual costs divided by the amount of electricity produced.

The annual costs result from the:

Cash value of annual costs,

One-off Payments,

Loan Payments

Self-Financing

Multiplied by the **Annuity Factor**.

9.6 Results Overview

The following payment sequences are available in the **Results Overview**:

- **Total Investments**
- **Total Operating Costs**
- **Total Consumption Costs**
- **Total Other Costs**
- **Total One-off Payments**
- **Total Disbursements/Savings**
- **Total Subsidies**
- **Total Loan Payments**
  Interest plus Repayments
- **Total Loan Interest**
- **Payment Received for Grid Supply**
- **Electricity Savings**
- **Self-Financing**
  Total of Investments, One-off Payments less Subsidies
- **Depreciation**
- **Result before Tax**
  Total of:
  -Operating Costs,
  -Consumption Costs,
  -Other Costs,
  -Subsidies,
  -One-off Payments
  -Disbursements/Savings
  -Payment Received for Grid Supply
  -Electricity Savings
  -Depreciation
  -Loan Interest
- **Tax Rebate**
  Is calculated using the Marginal Tax Rate from the Result before Tax.
- **Result after Tax**
  Result before Tax plus Tax Rebate
- **Cash Flow after Tax**
  Total of:
  -Operating Costs,
  -Consumption Costs,
  -Other Costs,
  -Disbursements/Savings
  -Payment Received for Grid Supply
  -Electricity Savings
  -Loan Payments
  -Self-Financing
  -Tax Rebate

- **Outstanding Loan Payments**
  Payments are listed here which at the time require interest and repayments to be paid.

- **Cash Balance (Accrued Cash Flow)**
  Total Cash Flow after Tax

- **Cash Balance less Outstanding Loans**

9.7 Economic Efficiency Calculation – Stand-Alone Systems

9.7.1 Economic Efficiency Calculation – Stand-Alone Systems

First of all you need to enter the parameters required for the Economic Efficiency Calculation. This is done on four different sheets:

Parameters

PV Costs, Breakdown of Costs

Back-up Generator

Financing

Once all the parameters have been entered you can view and print the results by clicking on the Economic Efficiency Calculation button.

9.7.2 Economic Efficiency Calculation – Stand-Alone Systems: Basic Parameters

The following parameters are entered on this page:

Capital Interest Rate

This is the interest on capital borrowed from the bank for the PV investment or the interest that could be charged on the capital used.

Price Increase Rates

Changes to running costs and fuel costs (if a back-up generator is to be used) are important for calculating the cash value of the system. Increase rates for electronics, batteries and the back-up generator can also be included.

Lifespan

The period given by the manufacturer as the expected lifespan of the system. For PV systems this is usually set between 10 and 25 years. The programme allows various lifespan periods to be entered for electronics, batteries and the back-up generator.

Economic Efficiency Calculation – Stand-Alone Systems

9.7.3 Economic Efficiency Calculation – Stand-Alone Systems: PV Costs, Breakdown of Costs

The following parameters for the PV system costs are entered on this page:

Investment

The investment can be given as an absolute amount or as a specific cost in €/kWp.

Subsidy

The subsidy can be given as an absolute sum, as a percentage of the investment or as a specific subsidy in €/kWp.

Running costs

The running costs can be given as an annual amount or as a percentage of the investment in percent per annum.

Component Cost Allocation

On this sheet the PV system costs can be split between its components: PV modules, electronics and batteries.

Economic Efficiency Calculation – Stand-Alone Systems

9.7.4 Economic Efficiency Calculation – Stand-Alone Systems: Back-up Generator

If a back-up generator is to be used, the costs are entered on a separate page.

Investment

The investment can be given as an absolute amount or as a specific cost in €/kW.

Running Costs

The running costs can be given as an annual amount or as a percentage of the investment in percent per annum.

Specific Fuel Costs

Fuel costs are entered as an amount per litre. The annual fuel requirement is shown after simulation.

Economic Efficiency Calculation – Stand-Alone Systems

9.7.5 Economic Efficiency Calculation – Stand-Alone Systems: Financing

Details on financing are entered on this page.

A loan can be loaded from the Database via the selection list or the folder button.

Loan capital

The amount of credit in € that is arranged.

Term

The time period that has been arranged for paying back the loan.

You also have to enter the **Annual Instalment** or the **Loan Interest**. In either case the other input field cannot be accessed and is calculated by the programme.

Annual Instalment

The set annual instalment which pays back the loan and interest within the credit term.

Loan Interest

The amount of interest that has to be paid on a loan.

If the loan interest rate is lower than the capital interest rate taking out a loan works like a subsidy, if the rate is higher the total costs increase. When interest rates are equal there is no difference.

Economic Efficiency Calculation – Stand-Alone Systems

9.8 Economic Efficiency Calculation – Grid Connected Systems

9.8.1 Overview of Economic Efficiency Calculation for Grid Connected Systems

You are able to move through the **Economic Efficiency Calculation** in two ways. With the **Continue** and **Back** buttons at the bottom of the window, you can go to the next or the previous page. With the left-hand **Navigation Bar** you can jump straight to the required page.

The Economic Efficiency Calculation consists of the following pages:

Calculation Basis

Basic Parameters

Balance of Costs

Investment Costs

One-off Payments (+-)

Operating Costs

Other Costs

Consumption Costs

Subsidies

Loans

Tax

Results

Graphics

Tables

Report

Every window contains a **Help** button (in the top right corner) which gives help in respect of the required entry parameters.

9.8.2 Economic Efficiency Calculation – Calculation Basis

This dialogue shows the basic parameters in PV*SOL which are relevant for the Economic Efficiency Calculation.

PV Peak Output:

The output of the system defined in PV*SOL under Standard Test Conditions.

(STC: 25°C module temperature, sunlight spectrum of AM 1.5 and 1000 W/m² irradiation.)

Electricity Supplied to Grid in First Year:

This specifies the amount of electricity fed into the grid in a whole year. The month that the system started operation and degradation are not allowed for here.

Electricity Costs Saved in First Year:

This specifies the cost saving made on electricity drawn from the grid in a whole year. The month that the system started operation and degradation are not allowed for here.

System Operation Start Date:

This date is required for the proportionate allowance for lodgements and disbursements made in the first year. **Investments**, **One-off Payments** and **Subsidies** arise independently of the date in the year that the system starts operation.

If the Start Date is in the second half of the year, only 50% **Depreciation** can be accounted for.

Costs that are settled annually are calculated proportionately in the year in which the system started operation.

Use Tariff to Calculate Feed-In Payment:

For the **Payment Received for Grid Supply** the following rule applies: the amount shown is paid, for example, for 20 full years plus the months in the first year of operation.

To Grid Tariff:

By clicking on the Load File button a To Grid Tariff can be loaded or amended.

Set Feed-In Payment:

In the field **Feed-In Payment for the First (X) Years**, you can directly enter the resulting feed-in payment.

Degradation

Degradation is the reduction in module power caused by ageing. You have the choice of entering a **Constant Degradation** for 20 years, or you can define a different degradation for each year.

Click on **Degradiation** to define the different levels of power loss for each year.

9.8.3 Economic Efficiency Calculation – Basic Parameters

Assessment Period:

Only complete years, not including the year in which the system starts operation, should be entered for the **Assessment Period**.

According to German standard VDI 6025, the Assessment Period is the time period of planning base for the calculation of economic efficiency (planning horizon).

The Assessment Period should be based on the investment with the shortest **Service Life**.

If the Service Life of an investment is less than the Assessment Period, the investment will have to be repurchased.

If the Service Life of an investment is greater than the Assessment Period, the investment will have a residual value at the end of the Assessment Period, which is included in the capital value calculation.

Interest on Capital:

The Interest on Capital can be entered as the Rotating Internal Rate of Return. The Rotating Internal Rate of Return is the average yield from fixed interest bonds. The German Federal Bank determines this from the average yields on outstanding debt securities. The Rotating Internal Rate of Return is therefore a measure of the interest level on the bond market.

Sales Tax

This entry field does not influence the calculation, but is there to make clear that all amounts should be entered either with or without sales tax. As a rule, all amounts should be entered as net sums. However, if you enter a gross amount, you should make sure that all entries are gross.

9.8.4 Economic Efficiency Calculation –Balance of Costs

On the **Balance of Costs** page you are able to enter all payments divided into cost groups.

The programme recognises the following cost groups:

- Tax Deductable Investements
- One-off Payments (non tax deductable)
- Subsidies
- Operating Costs
- Consumption Costs
- Other Costs
- Other Lodgements/Savings

If you want to enter a number of positions within a cost group, select the **Detailed Entry** for the cost group. This will automatically take you to the corresponding page, where you can enter as many positions for the cost group as you wish.

If you have selected the Detailed Entry on the Balance of Costs page, the field text is grey and the total of payments for the cost group is shown.

For each cost group you can choose to make absolute or specific entries, but this option is not available if the Detailed Entry selection has been made.

9.8.5 Economic Efficiency Calculation – Investment Costs

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

The **Price Change Factor** indicates the average percentage change of a payment in comparison with the previous year.

The **Service Life** is the time period measured in years of the economic use of an investment object.

If the Service Life of an investment is less than the Assessment Period, the investment will have to be repurchased.

The price of repurchase is based on the **Price Change Factor** given.

If the Service Life of an investment is greater than the Assessment Period, the investment will have a residual value at the end of the Assessment Period, which is included in the net present value calculation.

9.8.6 Economic Efficiency Calculation – One-off Payments

On this page you can define **One-off Payments**, arising at the time the system starts operation, and **Savings**.

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

One-off Payments are (unlike investments) costs which cannot be written-off against tax. They are taxed directly.

9.8.7 Economic Efficiency Calculation – Other Costs

On this page you are able to define any **Other Annual Costs**. .

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

The **Price Change Factor** indicates the average percentage change of a payment in comparison with the previous year.

9.8.8 Economic Efficiency Calculation – Operating Costs

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

The **Price Change Factor** indicates the average percentage change of a payment in comparison with the previous year.

9.8.9 Economic Efficiency Calculation – Consumption Costs

Here you can define the Consumption Costs.

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

The **Price Change Factor** indicates the average percentage change of a payment in comparison with the previous year.

9.8.10 Economic Efficiency Calculation - Subsidies

On this page you can define one-off **Subsidies** received at the start of system operation.

Click on **Add Position** to add a new position to the list.

To delete a position, first highlight the row by clicking on the appropriate cell in the first column and then click on **Delete Position**.

Subsidies reduce the costs. They do not influence tax depreciation, but are taxed directly.

9.8.11 Economic Efficiency Calculation – Loans

Number of Loans

Here you can enter the number of loans that you want to define. You can account for 0-3 loans.

Reference

Here you can give the loan a name, which will then appear in the Project Report.

Loan Capital

The amount of credit, with the calculation based on interest and repayment. The loan amount can be entered as an absolute figure in euros or as a percentage of the investment volume. **Investment Volume** is understood here as the investments plus one-off payments less subsidies.

Payment Instalment as a percentage of the loan capital (**Discount**)

This value specifies which percentage amount of the loan capital entered is actually paid.

The loan amount paid is based on the loan capital multiplied by the disbursement rate.

The **Total Disbursements** for all loans should not be greater than the Investment Volume defined above.

You will also need to define whether the loan is an **Instalment Loan** or an **Annuity Loan**.

Instalment Loan

With this kind of loan, repayments are made in equal instalments. The amount of interest to be paid is recalculated after each instalment from the remaining amount of debt. The total repayment amount is calculated from repayments which remain constant and interest on an amount which reduces over the period.

Annuity Loan

With this kind of loan, repayments are made in equal instalments over the repayment period. The loan repayment amount as a percentage of the instalment increases with the number of instalments, while the interest percentage sinks correspondingly.

Period

The loan-repayment period.

Loan Interest

Nominal Interest Rate to be paid on the remaining debt.

Repayment-Free Initial Years

During this period no repayments, but only interest payments are made. In the remaining time up to the end of the period, the loan capital is repaid in instalments.

Repayment Interval

Interest and instalments are paid at these intervals.

.

9.8.12 Economic Efficiency Calculation - Tax

In order for tax payments to be included in the **Economic Efficiency Calculation**, you will need to select the **Allow for Tax** field.

It is usually the case that with a profitable investment the inclusion of tax payments has a negative impact on the results. The results only improve with changing tax rates. A change in tax rate is possible, for example, if the investor retires after 10 years. If, at the time that the system starts to enter the profit zone, the investor is making losses on other investments, the tax rate could also be set at zero.

Marginal Tax Rate for Income/Corporation Tax:

This is the tax rate that needs to be paid for each additional taxable Euro. The amount should also appear in your tax assessment.

If **Allow for Change in Marginal Tax Rate** is selected, the **New Tax Rate** given in **Change of Tax Rate** comes into the calculation.

Depreciation Period:

The period over which the investment can be written-off against tax. The usual period for photovoltaic systems is 20 years.

Depreciation Type:

Linear:

Annual depreciation is calculated from the investment amount divided by the depreciation period.

Degressive:

Annual depreciation is not constant, but is calculated as follows:

Investments that have not yet been depreciated are multiplied with the rate of depreciation. This leads to a year by year decrease in the annual depreciation. If the annual depreciation sinks below the value that is obtained through linear depreciation, the residual value is calculated as linear depreciation for the remaining period.

9.8.13 Economic Efficiency Calculation - Results

The basic **Results** of the **Economic Efficiency Calculation** are shown here.

Exactly which Results are shown depends on the amount of self-financing being made towards the total investment.

The Results shown here also appear in the **Project Report**.

The system's **Net Present Value** and the **Electricity Production Costs** are always calculated.

The **Payback Period** and the **Net Yield** are related to the amount of self-financing used. Therefore these Results can only be calculated when the amount of self-financing is greater than zero. If the investment is partly financed by borrowed capital, the programme calculates a **Minimum System Operating Period**, following which the amount of self-financing used and the loan payments have been recouped.

If the Minimum System Operating Period is greater than the Payback Period, the Minimum System Operating Period is given.

Exactly which graph is shown depends on whether the Payback Period or the Minimum System Operating Period is given.

If the Payback Period is given, the **Cash Balance (Accrued Cash Flow)** graph is shown.

If the Minimum System Operating Period is given, the **Cash Balance less Outstanding Loans** graph is shown.

9.8.14 Economic Efficiency Calculation - Graphics

You are able to select whether and how interest is calculated on the Payment Sequences:

1. **Discount Payments (Cash Value)**
   The reference point for this method of observation is the time before the start of the **Assessment Period**. The discounted interest on all payments is calculated at this point. The results of the Economic Efficiency Calculation form the basis of this type of assessment (Capital Value, Payback Period, Internal Rate of Return, Electricity Production Costs).

2. **Interest on Payments**
   The reference point for this method of observation is the end of the **Assessment Period**. It can be interpreted as the balance of account.
   For a payment, eg of €1000 in the first year, interest is calculated at n-times capital interest up to the end of the Assessment Period, for a payment in the second year, at n-1-times.

3. **No Interest on Payments**
   A payment of, for example, €1000 in the first year has the same value as a payment of €1000 after 20 years. This gives a clear view, but is not suitable for making economic decisions.

You can display 2 curves via the selection fields. If you only want to see one curve, you should select <no curves> in the 2nd Curve field.

Print Graphic

The graphic displayed can be viewed via the Print Preview before printing. The page is fixed to print in horizontal format.

Copy Graphic

The graphic displayed can also be copied to the clipboard, for example if you want to add it to your project report in Microsoft Word. You would have to export the project report into Microsoft Word first – this is done via the Print Preview.

For information on compiling the results, see also Results Overview

9.8.15 Economic Efficiency Calculation - Tables

You are able to select whether and how interest is calculated on the Payment Sequences:

1. **Value of Payment Sequences (Cash Value)**
   The reference point for this method of observation is the time before the start of the **Assessment Period**. The discounted interest on all payments is calculated at this point. The results of the Economic Efficiency Calculation form the basis of this type of assessment (Net Present Value, Payback Period, Net Yield, Electricity Production Costs).

2. **Pay Interest on Payment Sequences**
   The reference point for this method of observation is the end of the **Assessment Period**. It can be interpreted as the balance of account.
   For a payment, eg of €1000 in the first year, interest is calculated at n-times capital interest up to the end of the Assessment Period, for a payment in the second year, at n-1-times.

3. **Do Not Pay Interest on Payment Sequences**
   A payment of, for example, €1000 in the first year has the same value as a payment of €1000 after 20 years. This gives a clear view, but is not suitable for making economic decisions.

In the table's second column, the total payments over the Assessment Period are shown. No totals are shown for the Payment Sequences that have already been accrued. In respect of the Investment Costs, the Residual Value of the investment at the end of the Assessment Period is given in the final column.

Copy Table

The table displayed can also be copied to the clipboard, for example if you want to calculate your own results or to create your own graphics from within a spreadsheet programme.

For information on compiling the results, see also Results Overview

9.8.16 Economic Efficiency Calculation - Report

Here you are able to select the items that will appear in the **Project Report**.

The **Results Overview** gives details of the actual results, and this should always be printed out.

In addition, you can print a **Detailed List of Income/Expenditure**. This shows all the entries specified under the headings **Balance of Costs** and **Loans**.

You can also select which graphics you would like to appear in the report.

Click on **Print Preview** to take a look at the pages included in the report. From here you can print the report and create a PDF file. You can also export to Microsoft Word or other word processing programmes that accept documents in RTF format. You are then able to change the report layout, for example.

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